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AIM

The aim of the Journal of Design Studio is bringing different design studio researchers together on a multidisciplinary design studio research platform. This design studio research platform gives the researchers who made experimental studies in their design studio education to share their works with the other researchers in the same area or similar research fields. The scope of the Journal of Design Studios include all research and experimental works realized in all type of design studios.

SCOPE

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Design principles for studio work,
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Innovative and creative works in design studios
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Editorial

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Editorial
This issue of the Journal of Design Studio features one book review, eight research articles, three review articles, and one design studio case study. Among the research articles, seven are peer-reviewed papers presented at the MİTA 2024 National Symposium on Architectural Design Research. I would like to extend my gratitude to Assoc. Prof. Dr. Güliz Özorhon and Assoc. Prof. Dr. İlker Fatih Özorhon, who served as guest associate editors for the evaluation of these articles. Additionally, the Journal of Design Studio has recently been indexed by ERIHPLUS.

The first article in this issue, titled "Contextualizing Co-Working Spaces: User Participatory Approach in Architectural Design Studio" by Ekrem Bahadır Çalışkan and Çiğdem Koç Aytekin, explores the impact of user participation and the limitations of actor diversity, with a specific focus on the university campus area within a new and emerging context.

The second research article, "Systems Thinking as a Methodological Approach to Study Infrastructure Space in Architectural Design Education," is written by Derin İnan, Başak Uçar, and Onur Yüncü. This paper discusses the outcomes of integrating systems thinking into architectural education, particularly the reconceptualization of ‘infrastructure space’ as a useful tool for addressing the complex structures of urban environment

Cansu Günaydın Donduran, Altuğ Kasalı, and Fehmi Doğan authored the third research article, "Artificial Intelligence as a Pedagogical Tool for Architectural Design Education." This study explores the impact of AI on design pedagogy, offering insights into how these developments are shaping the evolving landscape of architectural education and contributing to ongoing debates about AI’s role in the field of design and architecture.

The next article, "Bibliometric Analysis on Artificial Intelligence Aided Architectural Design," is written by Fulya Pelin Cengizoğlu. This study aims to explore the role of AI applications in architectural design. The paper presents a bibliometric analysis of 137 articles related to AI in architectural design, published between 1991 and 2024, using the Web of Science (WoS) database.

"Integrating Text-to-Image AI in Architectural Design Education: Analytical Perspectives from a Studio Experience" is the title of the article by Sinem Çınar and Melek Demiroz. This paper examines the integration of AI, specifically text-to-image tools, into architectural design education, focusing on their application in a third-year design studio project at Atılım University.

The following research article in this issue is titled "First-Year Architectural Design Studio in Action: Insights from the ‘Timberscapes' Design-Build Experience," written by Göksun Akyürek, Nilay Ünsal Gülmez, and Ayşe Eda Adıgüzel. This paper examines a case study that highlights the creation of a dynamic negotiation environment in a first-year architectural design studio, as well as the practical limitations and future implications of the applied process.

The article titled "Material !Ndeed: Workshop Series as a Hyper-Focus Niche at the Intersection of Material Selection and Architectural Design Tools" is authored by Yağdır Çeliker Cenger and Aslihan Ünlü. This study explores the "Material !Ndeed" workshop series conducted during the summer semesters of 2021-2022 and 2022-2023 at Özyeğin University's Faculty of Architecture and Design. The research assesses the influence of these workshops on design education, emphasizing the hyper-focused learning approach and the educational methods employed.

The article "Starting in the Middle: A Method Trial," written by Erdem Üngür and Aygen Erol Çakır, examines the outcomes of the 2015 "Architecture Schools First Year Studio Meeting II" workshop. It documents and analyzes the curriculum of the MIM121 Architectural Design I studio, reflecting on the studio's unique perspective and approach. Ten years after the workshop, which identified the challenges and objectives of first-year architecture studios nationwide, the authors aim to evaluate their own studio within the context of the workshop's results, contributing to its findings.

Seyedehzahra Shafa authored the research article titled "Ranking of Smart Building Design Factors with Efficient Energy Management Systems and Renewable Resources." The study seeks to rank the design factors of smart buildings, focusing on efficient energy management systems and renewable resources. The research is applied and objective in nature, utilizing a descriptive-survey approach for data collection.

The next article, authored by Duygu Beykal İz and G. Zeynep Karapars, is titled "Measures of Information Visualizations in Design Studio Education: Designing Climate Change Visualizations." This study enhances the fields of information visualization and communication design by proposing measures to improve climate change visualizations and offering insights for teaching these concepts in communication and graphic design studios.

"A Comparative Study on Philosophy, Epistemology, and Methods of Teaching in Design Studios in the Beaux Art, Polytechnique, and Bauhaus: Regeneration, Development, or Transformation?" by Rahman Tafahomi aims to investigate philosophical and epistemological foundations in collecting knowledge in three important schools of architecture including Beaux Art, Polytechnique, and Bauhaus.

Seyedehzahra Shafa is the author of the review article, "Smart Materials in Green Architecture: The Role of ETFE and Phase Change Materials in Sustainable Building Design." This article introduces intelligent materials, focusing on their applications and benefits in green building architecture, with an emphasis on their performance and behavior in architectural designs, based on library studies.

The review article "Sustainable Fabric Manufacturing: The Crochet Experience," authored by Ngozi Kesiah Okeke, advocates for teaching crochet skills to local textile manufacturers as a sustainable alternative to conventional fabric production processes. The approach aims to reduce the environmental impact of traditional methods while providing job opportunities for unemployed youth in Nigeria.

Rabbia Tanveer authored the Design Studio Case article, "Teaching Aperture Design in Architecture: A Pedagogical Approach to Illumination, Structure, and Space." This study examines the application of experiential learning models in architecture, demonstrating that hands-on design tasks, supported by interdisciplinary faculty, can significantly enhance students' technical and conceptual knowledge.

Finally, Yasemin Erkan Yazici reviews the book "Traditional Window Designs of Kirklareli, Turkey," authored by Nevnihal Erdoğan and İzzet Yüksek, and published by Bentham Science Publishers in 2013. The review provides a comprehensive overview of the book and its content.

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Contextualizing Co-Working Spaces: User Participatory Approach in Architectural Design Studio

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Abstract: The evolution in our understanding of the notion of 'working' has evolved into a spatially diverse spectrum over the last decades. The era of increasing new definition of working enabling collaboration, knowledge sharing and socializing among users is worth of attention in terms of contextual use. Since the popularity of coworking spaces has increased over years, the variation of use contexts is gradually increasing. Thus, it becomes clearly important for designers to take the phenomenon of target users in specific co-working places into account throughout the design process. This study explores the effects of user participation and limits of actor diversity, with an approach focusing spesifically on the university campus area within the new emerging contextual diversity. User participation design method has been tested in the bachelor degree architectural design studio in the Department of Architecture in Ankara Yildirim Beyazit University. The purpose of this study is providing the understanding of the relationship between design process and behavioral patterns with the knowledge obtained through data collection based on user preferences and final versions of the projects.

Keywords: User participation, Co-working space, Design studio, Architecture, Campus design.

1. Introduction

In recent years, globalization, the pandemic process, and technological advancements have led to the emergence of new forms of production/consumption, including novel forms of collaborative organization. Collaborative working is emerging as one of the manifestations of these evolving processes within this current social and organizational scenario (Ivaldi et al., 2018). The tools and architectural environments are also being updated along with the working models. Co-working spaces are distinguished by their exceptional adaptability regarding access, which is contingent upon individual work schedules. They feature diverse functions within the same spatial context, fostering a distinctive blend of domestic and business ambiance (Kingma, 2016).

The prevalence of co-working spaces has witnessed a notable escalation (Gandini, 2015). There is a trend for organizations to open their workspace to the wider community and invite others to share the space. The new working model is increasingly intriguing for practitioners, academics (Waters-Lynch et al., 2016) and students. University campuses can also move away from libraries designated solely as places for reflective study and into learning commons of informal and ad hoc collaboration. For Matthews, in the context of academic facilities, it is crucial that spaces are designed to facilitate and enhance the learning experience (Matthews et al., 2011). Co-working spaces on campus can provide a community workspace with shared services that allow individuals and small groups to share ideas and mutually support each other's work. Thus, this paper seeks to answer the research question: How might this space be characterized within university campuses as a specific context?

These spaces represent dynamic and invigorating workplaces, fostering interactions among individuals from diverse professional domains facilitating knowledge exchange and collaborative creation (Fuzi, 2015). In addition to attracting individuals with different profiles and fostering social interactions, these spaces also enhance productivity and promote knowledge sharing among colleagues. University campuses can also move away from libraries designated solely as places for reflective study and into learning commons of informal and ad hoc collaboration. Co-working spaces on campus can provide a community workspace with shared services that allow individuals and small groups to share ideas and mutually support each other's work (Bouncken, 2018). Thus, the design characteristics of these environments can be customized and adapted based on the profiles of the individuals involved. However, not all end-users have the same motivations for choosing these spaces. The motivation criteria are user-based needed for types of work in the university environment, when transferred to the design process, can be beneficial for contextualizing co-working spaces into the campus environment. In this way, it might create the opportunity to question the multi-possible nature of architectural production through user preferences. In other words, user preferences can serve as a foundation for the value propositions of co-working models. However, there is still very scarce research on user preferences regarding collaborative workspaces. This study aims to reveal how the identified requirements, within the context of the user-participatory method, affect the architectural environment on the campus, in what ways, and what typological diversities are created. Furthermore, it seeks to explore how these diversities can be interpreted in terms of spatial identity through various stakeholders. In other words, it aims to discuss the effects of involving actors in the design process on co-working spaces specialized for the campus environment through student projects produced in an architectural design studio as a basis for analysis.

This paper reports testing a user-participatory design approach in a co-working space in a bachelor's degree architectural design studio. Two parts will conduct this twofold approached research. The first part will deal with the literature survey, and then the findings section will present the students’ data collection, the final results of the projects, and their feedback. Finally, the paper concludes with the final words providing the inferences for future studies.

2. Theoretical Background

2.1. Participatory Design Studio

Architectural design education follows a trajectory centered on studio courses, necessitating an environment conducive to creativity and experiential learning. Within the design studio, students acquire the essential skills for creative problem-solving and cultivate a capacity for critical thinking (Yurtkuran et al., 2013). In conjunction with evolving needs and perspectives, conventional design philosophies' novel and alternative methodologies have commenced their integration within the doctrines of numerous architectural design studios. Recognizing the significance of context and the conviction that design should not be perceived as a singular process necessitate the proposition of innovative approaches that will enrich students' comprehension of design from the standpoint of users and stakeholders (Shanthi Priya et al., 2020).

In design studios, the most challenging phase for students is often the preliminary phase of the design. In this phase, they must determine the main idea and concept. Participatory and collaborative models can be a beneficial situation for students to transform the data they access from library and internet resources into ideas. Introducing participatory design within the context of an architectural design studio aims to empower students by enhancing their comprehension of both the physical and social aspects of the environment. This approach encourages students to appreciate these elements and equips them to make informed decisions (Salama, 1995). As a research tool, this method enables students to discern and obtain the information necessary for the design process by developing a sensitivity to listening to customers and users.

Various stages of user participation are mentioned, from passive to active: 1- in the early decision-making, 2- during the design process, and 3- post-occupancy addition/modification works. The least active mode of engagement is realized through the architect's deliberate attentiveness to the preferences and individual requisites of the client or user. This embodies the favorable aspect of the architect's function as an intermediary, decoding both overt and covert articulated wishes, aspirations, and visions of the intimately acquainted client. The impact of the client on the architectural progression and its outcome is facilitated by the architect's adeptness in empathetically assuming the client's perspective (Wulz, 1986).

2.2. Re-thinking Co-working Spaces

The organizational and spatial arrangements of workspaces are undergoing alteration. The extraordinary shifts in our daily routines, the rapid advancement of digitalization, and the widespread adoption of remote work as a response to the global pandemic have given rise to significant inquiries concerning commuting, the utilization and function of office premises, the evaluation of space efficiency, the magnitude of office space demand, and the necessity for a more adaptable work structure. Consequently, organizations spanning diverse sectors must envision a transformed paradigm for future office work. This novel office paradigm facilitates the effective functioning of individuals with diverse profiles within a communal workspace, promoting shared collaboration and social interaction among coworkers (Isac, 2019).

With universities closed over the pandemic, students turned to co-working spaces to maintain safe in-person collaboration and grab time away from the distractions of shared living. These spaces offer many advantages for self-starters, including networking opportunities, daily structure, increased productivity, and an alternative to pending the nine-to-five in a dull desk cubicle. It is theorized that freelancers with flexible work hours work better if surrounded by others. Moreover, in a time of backward-looking concern for the future of libraries, understanding the function of these public spaces needs to be re-defined to expand the horizons of the vision for university libraries in this century. As a sign of a public facility and a learning space, a university library has a future as a place to meet, read, share, and explore ideas in what might be called a ‘living room on the campuses.

3. Studio Case Studies

3.1. Studio Set-up

This studio was spread over a fifteen-week bachelor degree architectural design studio during the Spring semester of the 2022-2023 academic year at Ankara Yildirim Beyazit University. In this studio, focusing on our university campus, students are expected to deal with “Co(l)lab Scapes”, which is a term offered by the studio that includes the semiotic meaning of the co-working and library spaces together; students were expected to offer communal facilities where students of various fields and departments can work alongside each other, collaborate and share sources, thus creating a symbiotic relationship linked to a common workplace. These environments should foster productivity and collaboration, leading to introverts and extroverts. All of the students in the studio focused on a co-working facility design for the selected users by the studio teams from various university departments and publicity. Besides the co- working spaces, third-year students considered what library spaces are for and what that means for the university students' decisions today. Regarding truly innovative design, “Co(l)lab Scapes” should

Figure 1: *The present situation of the campus area (on the left), the planned site plan for the future (on the right) (Source: Author)*

appeal to some balancing parameters: socialization, mix of used spaces, change of scenery, and context. Re-imagining these four and how education is delivered and the role of the campus, the students dealt with the existing assets of the university, the own scape, and the environmental acts.

3.2. Data Surveys

Understanding user preferences in studying coworking spaces necessitates the identification of key attributes that have the potential to either fulfill or disappoint specific user inclinations (Appel-Meulenbroek et al., 2021). With this understanding, the studio students collected data from different sources, such as literature reviews, observations, and interviews. They were free to choose to work either individually or in groups. They visited different co- working spaces in the living city to understand the work environment and social practices. They observed and understood users' practices in the workspaces. Besides, they interviewed students, dormitory users, professors and assistants from various university departments, and independent users such as freelancers,

Table 1: *Data surveys and leading questions for user participation (Source: Author)*

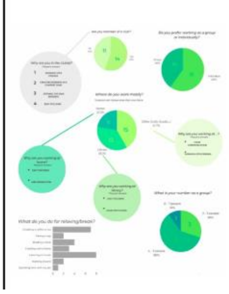
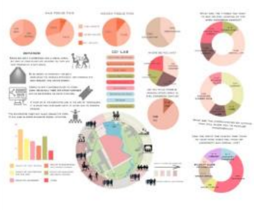
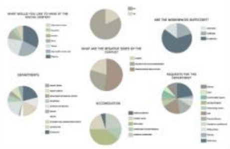
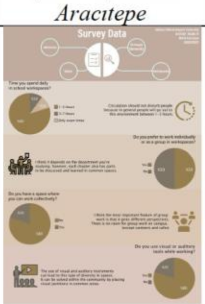
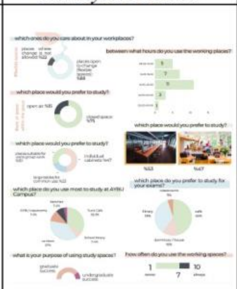
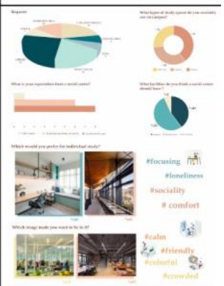
Cases	Case 1	Case 2	Case 3	Case 4
Project Name	***'Practix Hub'*** *by Ayşenur Demir*	***'Productive Mind Hub'*** *by İrem Gök*	***Research Junction'*** *by Yunus Emre Gencer*	***'Journeys'*** *by Hatice Ceylan*
Survey studies				
Leading questions for the conceptual backgrounds	• Where do you study mostly? • Are you a member of any student club? • Why do you prefer student clubs?	• What are your expectations from a working space? • During which period do you work mostly on campus?	• What do you want to see or feel missing in your campus area? • Do you prefer working as a group or individually?	• What is your department? • Please mark the images showing the conditions you would like to work in.

Table 1: *Data surveys and leading questions for user participation (Source: Author)*

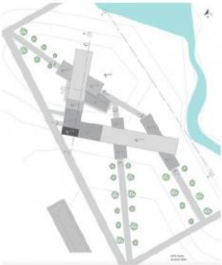
Cases	Case 5	Case 6	Case 7	Case 8
Project Name	***'Mutualist Space'*** *by Merve Özdemir*	***'Social Working Space'*** *by Melih Aracıtepe*	***'Development Beyond Schools'*** *by Rümeysa Kırmızı*	***Informaction'*** *by Zehra Su Varol*
Survey studies				
Leading questions for the conceptual backgrounds	• What would you request for studying? Which department are you studying at?	• Do you think there is enough space for studying collectively? • Do you use any visual or auditory tools while working?	• Which place do you prefer to study for your exams? • Which one would you prefer: open or closed spaces?	• What are your expectations from a social center? • What facilities do you think a social center should have?

coaches, or entrepreneurs to collect more profound insights. Data were obtained by asking participants questions such as gender, age, level of education, academic field, and criteria determining their motivation for collaborative work. "With this understanding, the studio students collected data from different sources, such as literature reviews, observations, and interviews (Table 1).

3.3. Final Projects

Case 1.

This project, which put 'student clubs' as the focus of the conceptual idea, tries to create more comfortable, natural, and flexible environments for university students specifically with small teams. Student clubs are creating groups and collaborative activities for their working aims and have unique assembly types. Combining different spaces and intersecting the main areas with main effects creates different options for working in wanted areas. Besides, unique areas



such as ‘capsules’ help with isolation or silence for individual and group workings.

This project aims to enable people from different fields to interact and work efficiently with the workspace. Meditation is accepted as the main idea since it is thought to affect motivation positively. The spaces are designed to communicate with natural elements, such as in a direction toward a river. The spaces are arranged by establishing an organic connection with topography. Besides, individual workspaces aim to establish a direct relationship with the landscape, taking into account environmental distractions. The court created below, and the zones allocated to the river provide sociality, work, and meditation.

Since the land on which the designs are is an area that brings people from different fields, ages, departments, and faculties together and enables them to work together, this project aims to maintain people’s own working experiences and participation activities at junction points. Thus, the concept is to produce spaces offering multi-purpose and flexible use, where people can be together even if they work with different training methods. The buildings as a whole formed a courtyard in the center. The junction formed in this region is the heart of the region. Studying, sociability, movement, and a healthy working environment come together here. It is also an environment where workshops, group work, seminars, and conversations are held. In addition, by dividing the courtyard it creates into different zones, the idea of intersection is tried to be strengthened.

As workspaces have become a part of people’s lives, these places can vary according to people’s preferences. Here, the concept offers users ‘journeys’. Different users may come to this place for different purposes. The ‘routes’ will have different scenarios and journeys, but some spaces may be the common point of these scenarios: ' research’, ‘collaboration’, ‘seminar’, ‘working’, ‘interactive art’, and ‘library’ routes.

Case 2:

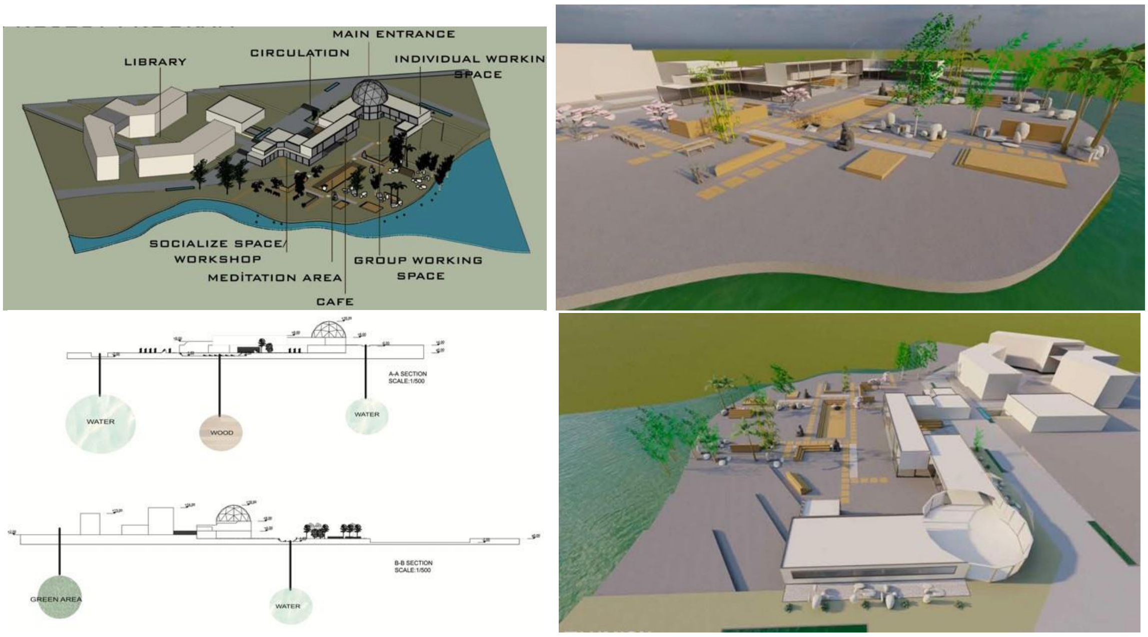


Figure 3: *‘Productive Mind Hub’ (Source: Author)*

Case 3:

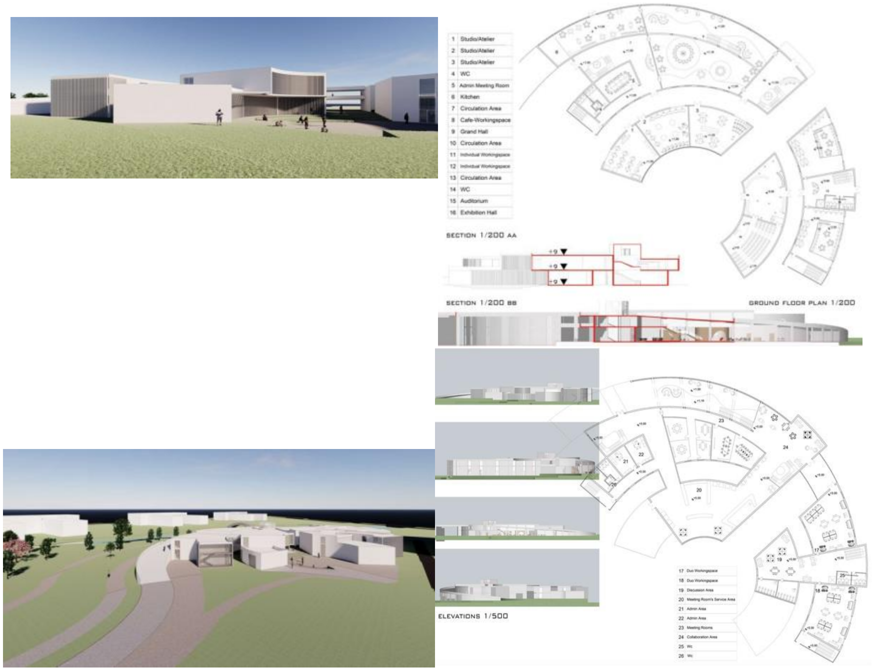


Figure 4: *'Research Junction' (Source: Author)*

Case 4:

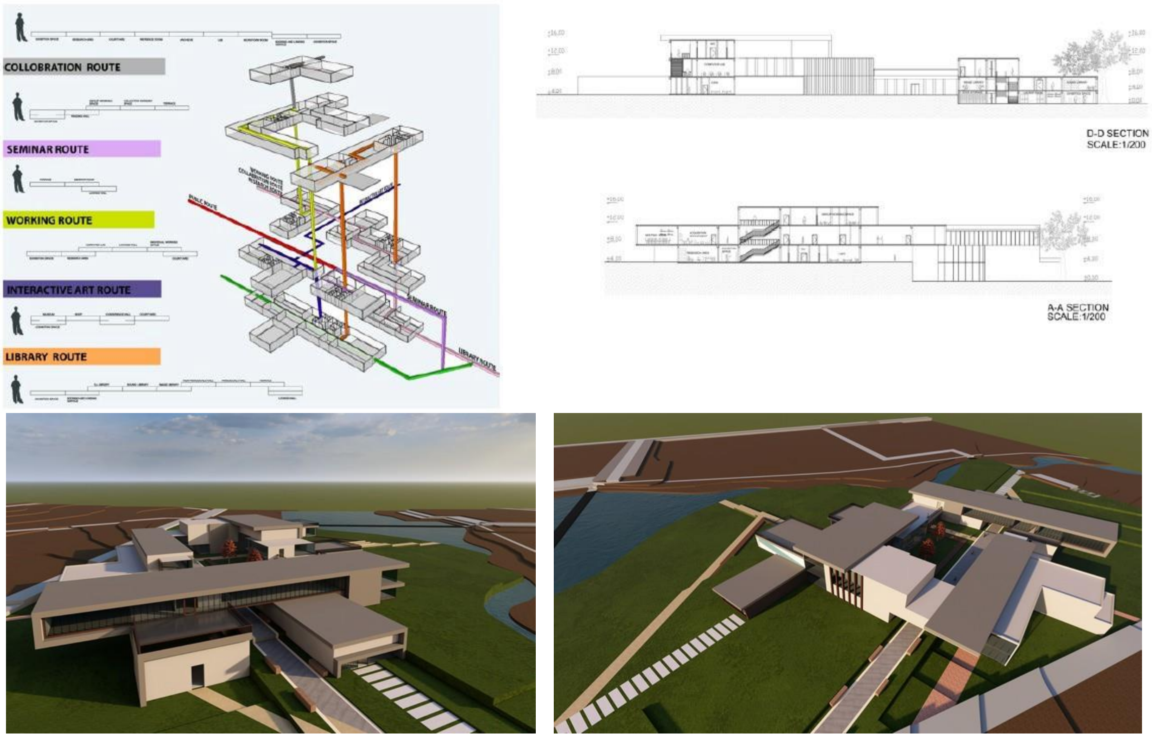


Figure 5: *'Journeys' (Source: Author)*

Case 5:

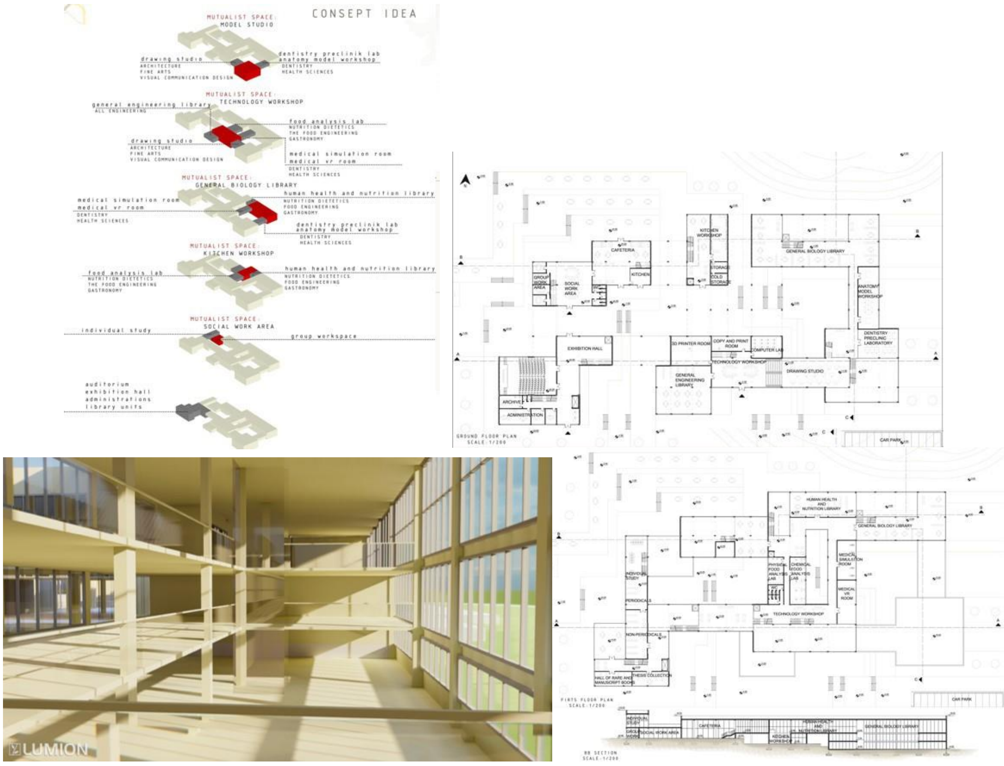


Figure 6: *'Mutualist Space' (Source: Author)*

This design approach includes spaces for the needs of students from different departments. The project has spaces for joint study areas and skills of students. As a concept idea, these spaces are called Mutualist spaces. Because these places are thought to be places where people from different departments will come together and benefit from each other. The first of the mutualist spaces is an interactive space with a model studio, drawing workshop, dental preclinical laboratory, and anatomy model workshop. The second mutualist space is a technology workshop, which interacts with the engineering library, the food analysis laboratory, the drawing studio, and the medical simulation room. The third mutualist space is the general biology library. This place is fed from the medical simulation room, the nutrition library, and the dentistry room. The fourth mutualist space is the kitchen workshop. This place is located in the food analysis laboratory and interacts with the human health library. Finally, the social mutualist space serves as a bridge between the individual study and group study areas, and students work here in a way that they interact with each other. Apart from these are library units, exhibition space, and conference hall.

This design proposes 'social working spaces' to users from similar fields. The term is defined as belonging to a community, accessibility, and sustainability. As a new way to work and share, these spaces aim to provide a productive and

Case 6:

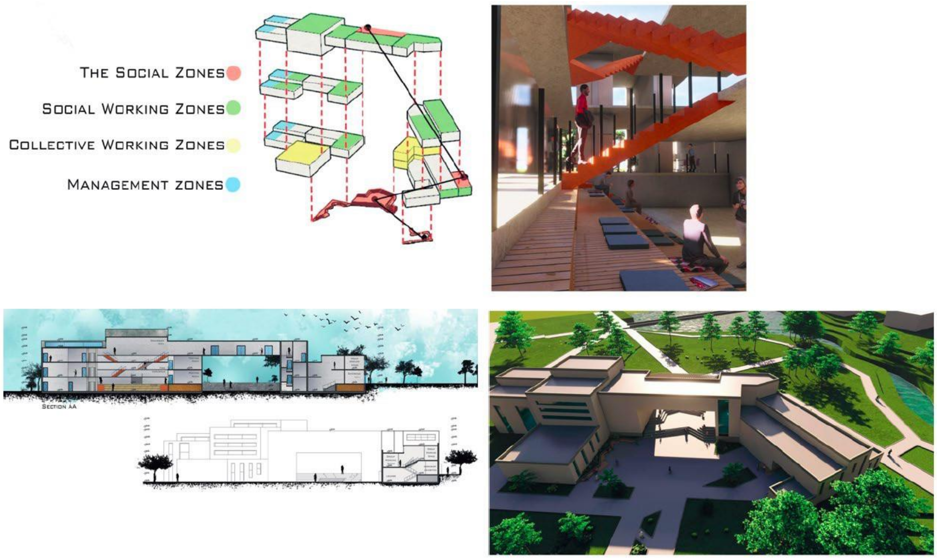


Figure 7: *'Social Working Space' (Source: Author)*

collaborative environment. At the same time, the presence of people interested in similar subjects in the same environment allows them to gain unique experiences. Social working space is not working individually in a social environment but in a working environment where people support each other. The spatial organization was shaped through social, collective, and social zones.

This project approaches working with students, academics, and professionals together. Since

Case 7:

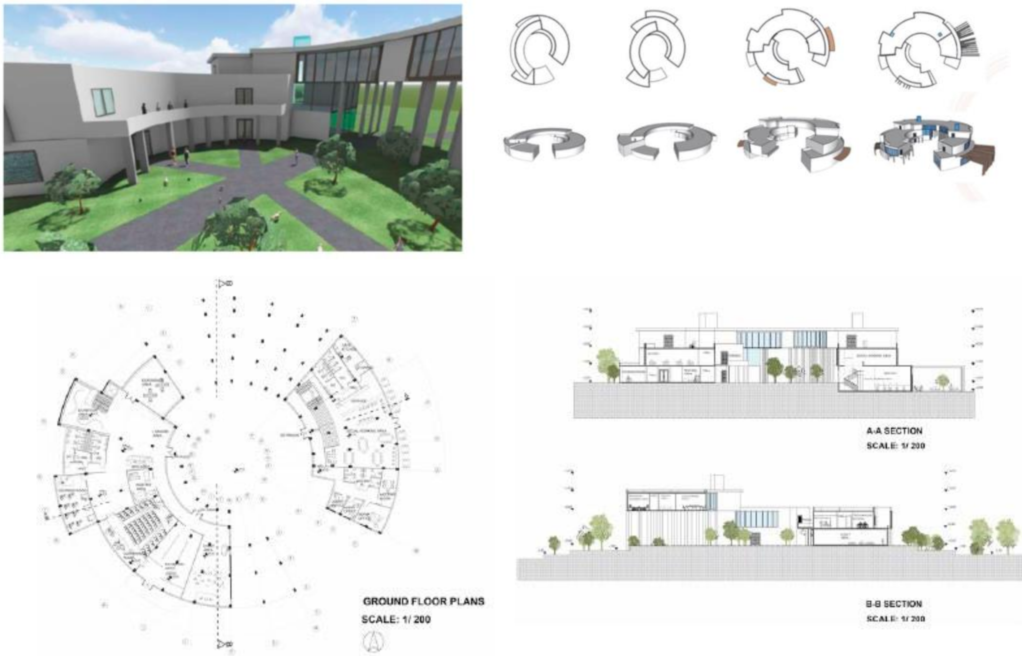


Figure 8: *'Development Beyond Schools' (Source: Author)*

Case 8:

Figure 9: *'Informaction' (Source: Author)*

the students cannot interact the professional people except for short period internships, this design concept may help to share the knowledge and move the professional practice to the undergraduate education.

Here, it is aimed that users share what they have learned and experiences and share knowledge while learning, thus contributing to their development both socially and academically. ' Informaction' is accepted as a context denoting knowledge and interaction. Open and semi-open areas are created for this knowledge transfer within the project's scope. In addition, the group, individual, silent working areas, and mixed usage areas for workshops and conferences are designed to create interaction.

4. Evaluations

Table 2 shows the pattern of design processes. The presented cases are discussed and evaluated; then, the projects are outlined in four parts: conceptual idea, target users, space requirements, and characteristics. Following the order and inquiries of the table, all project cases are figured out in terms of the relationship of the spaces with conceptual ideas and target users. Thus, the user knowledge implementation's contribution to the studio projects could be opened to discussion. The users of multi-tenant office designs come from different backgrounds. They include users from different fields, departments, self-employed people and others. The spaces mostly associated with multi-users are related to access to social contacts. This is mostly achieved by introducing spatial organizations that enhance user interactions, including formal/informal encounters such as café, seminar rooms or group working spaces. The sense of belonging a place is tried to be achieved by offering different experiences for target users, such as using more visible and accessible units. Besides, some offices offer flexibility due to being on-demand office spaces that are economically affordable.

The acquired data can be evaluated and compared under several main headings. Firstly, one of these is whether design processes are conducted through specific target groups. Based on the data collected through the user participation method, the majority of designers directed their concepts towards users who could be grouped based on specific characteristics. Some designers focused on creating designs for current undergraduate and graduate university

Table2: *Design stakeholders of the case projects (Source: Author)*

	Conceptual idea	Target users	Space requirements	Space characteristics
Case 1	*Student clubs provide the feeling of being part of a community, creating ideological boundaries and students' comfort zones.*	*small teams of university students,*	• *Open spaces* • *Mentor offices* • *Meeting areas* • *Small-sized private areas*	• *Privacy* • *Sociability* • *Isolation* • *Interaction*
Case 2	*Meditation reduces stress, increasing focus, creativity, and inspiration*	*university students, academics, researchers*	• *Green areas* • *Pastoral views* • *Natural elements*	• *Privacy* • *Relaxation* • *Isolation*
Case 3	*Co-working spaces as an intersection point that brings people from different fields, ages, and departments together*	*open for everyone*	• *Workshops* • *Courtyards* • *Interaction areas*	• *Sociability* • *Linearity* • *Flexibility* • *Movement*
Case 4	*Journeys are offered to people from different fields for different purposes.*	*open for everyone*	• *Exhibition space* • *Group and individual working spaces* • *Café* • *Conference hall* • *Research area*	• *Collaboration* • *Interaction* • *Accessibility* • *Sociability* • *Flexibility*
Case 5	*Mutualist space design for students from different departments benefiting from each other (activity-based specialized)*	*University students from different departments*	• *Technolo gy workshop* • *Biology Library* • *Kitchen workshop* • *Model studio*	• *Interaction* • *Flexibility* • *Openness* • *Sustainability* • *Adaptation*
Case 6	*Social working space provides an environment where people from similar fields contribute to each other.*	*People from similar fields*	• *Common areas* • *Collective working areas* • *Social working areas*	• *Interaction* • *Linearity*
Case 7	*An approach proposes an environment that embraces professionals from the private sector and university students.*	*Professionals, academics, and university students*	• *Studios* • *Offices* • *Quiet study areas* • *Group study areas* • *Classes* • *Conference rooms* • *Event areas*	• *Collaboration* • *Isolation* • *Togetherness*
Case 8	*A complex design embraces knowledge and interaction for transferring information while learning socially and academically.*	*University students and academics*	• *Mix usage areas* • *Social areas* • *Open-semi open spaces*	• *Centrality* • *Accessibility* • *Collaboration* • *Openness*

students studying in various departments, while others preferred targeting students from similar fields. Essentially, this effort enabled architecture students to realize the existence of diverse student groups and researchers within the university with very different needs, prompting them to step outside the confines of their own environments. However, some designers attempted to create hypothetical user groups by associating user groups outside the university (mentors, industry professionals, etc.) with their established concepts. This was valuable in terms of not only considering the current state but also anticipating potential future changes. In any case, it is possible to observe that students' efforts in user grouping resulted in an attempt to understand the behaviors and activities of users. In doing so, they endeavored to create scenarios for spatial organizations and align them with their conceptual ideas. As an example, in a project (Case 7), there are professional employees who will join the user groups from outside. The spatial features aim for specialization that facilitates collaboration while ensuring the separation of activities. The concept created in this scenario is compatible with the goal of providing external experience and knowledge transfer to the university. In another example (Case 8), the user group is defined broadly as existing university students and academics. However, in a project where knowledge transfer is the focus, a spatial feature heavily influenced by user groups has not been clearly articulated among them.

The direct relationships established between activity definitions and target groups are discernible through the resulting products. For instance, in a project aiming to bring together students working in similar areas with social work offices (Case 6) and another project (Case 5) intending to design mutual spaces for students studying in similar departments, both projects aim for interpersonal knowledge transfer, resulting in the creation of spatial characters such as 'interaction.' In the project focusing on the coexistence of similar areas, flexible common areas serving a general purpose were attempted to be defined, gathering users engaged in similar research fields in these spaces. In the other project (Case 5), university students were classified based on the spaces required by their education, and the individual requirements and potential needs of these spaces were identified. This allowed the combination of seemingly unrelated departments. For example, a model studio envisioned for architecture students is simultaneously intended as a model workshop for dentistry students. On the other hand, when looking at designs that do not aim to serve a specific user group but rather create spaces for everyone (Case 3 and Case 4), it can be observed that the spaces are characterized through 'flexibility' and 'sociality.' In fact, in these projects, the designers have claimed the following after conducting user research: if students need private spaces at a university, they should find them within their own departments. When users come to co-working spaces for work, socialization, and collaborative activities, they should find areas that provide flexibility and communication. In concepts oriented towards specialization for individuals and small groups (Case 2, Case 1, and Case 7), it is evident that emphasis is placed on individual spaces, and this effect is conveyed through a spatial character like 'isolation.' The most crucial research finding underlying these studies is that users have identified the need for spaces where they can work individually or in small groups.

5. Conclusion

Throughout the semester, students produced various building typologies in line with the needs of various user groups and different concepts. Through this method, within the scope of the studio, user data is considered as a form of information at the outset and is integrated into the process. It is acknowledged as a tool for directly or indirectly transforming new information into the final architectural product within the process. In professional practice, the utilization of information, requests, and problems from actual users to determine the designer's project objectives, ideas, and spatial needs holds a significant place in both practical application and literature. The endeavor of students to define projects and manage the process based on the desires of real users is a crucial experience. It can be said that the participatory design method is more efficient than the traditional method because users' input provides greater clarity in design decisions and approaches design from multiple perspectives. Compared to the traditional method, where concept production is more arbitrary, clearer ideas were obtained in determining the issues to be addressed in the design with the participatory method. The fact that this method is closely linked to real needs and is specific to the context, people and culture has prevented the production of approaches based on assumptions.

The collaborative and participatory process not only widened the designer's perspective on user opinions, requirements, ideas and solutions but also facilitated direct feedback and critical comments from users in the design studio. Implementing this approach in the project and conceptual stages proved beneficial, with user-generated ideas contributing significantly to the students' design formulation. Although the aforementioned participatory and collaborative model was applied in a single studio, its potential adoption in architectural education curricula signifies a transformative shift in teaching methodologies within traditional architecture schools and the professional realm.

It is considered important that the designer, beyond having a role of designing with the data at hand (site, architectural program, other), is both a designer and a constructor by establishing the context and architectural program together with external stakeholders and factors. In this study, the importance and contribution of students experiencing this role in studio education was evaluated.

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Systems Thinking as a Methodological Approach to Study Infrastructure Space in Architectural Design Education

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Abstract: In architectural education, urban-scale studies provide an opportunity for architectural students to study the challenges that cities confront and their physical and conceptual frameworks with a multidisciplinary approach. The design process necessitates the critical evaluation of the inputs that define, structure, and govern the cities and the acknowledgement of social, economic, ecological, geographical, and experiential conditions. The critical reading of the city also demands an understanding of its prevailing, speculative, and emergent conditions, which can be apprised through a cohesive structure of relations shaped by directives from various agents. Advocating for a novel methodological practice in architectural education, this approach fosters the engagement of architecture students with the networks, constellations, and associations of contemporary urban conditions.

With this conceptual framework, the paper speculates on the potential of introducing systems thinking as a methodology for architectural education, which encourages the study of interrelations between different parties, in diverse scales, to design contemporary urban conditions. It subjects students' works in the fourth-year architectural design studio, where systems thinking is acknowledged as a methodology to study the notion of infrastructure space. In these studies, infrastructure space is considered as the site of multiplicities, coexistences, and overlaps beyond its typical association with "physical networks for transportation, communication or utilities" (Easterling, 2014). Studying the infrastructure space through a systems thinking approach is believed to enable the integration of inchoate states and territories of local, trans-local, and global occurrences. To sum up, the paper will discuss the outputs of integrating systems thinking in architectural education, and the reconceptualization of 'infrastructure space' as an instrumental approach in dealing with the complex structure of cities.

Keywords: Architectural education, Infrastructure space, Systems thinking, Design studio.

Introduction

Contemporary cities have started to be defined as the sum of interconnected and dynamic systems, where the invisible infrastructural networks play a crucial role in shaping the urban experience. Prioritizing connectivity, interaction, and flow over static conditions, contemporary cities today can be argued to operate as complex networks of connections, which require continuous adaptation and adjustment. Therefore, addressing these complexities necessitates an interdisciplinary approach that incorporates insights from various fields, including ecology, technology, and social sciences. This broad perspective can be argued to assist the development of resilient and innovative solutions for urban challenges and allow for more responsive and adaptable urban environments. However, updated definitions of contemporary cities necessitate new methodologies and strategies for their understanding and design. Strategies developed to understand the multi-layered structures of cities can be essential inputs for enabling different readings of cities and their structuring, such as the infrastructure spaces and networks that make them exist.

In understanding the dynamics of urban conditions, infrastructure space can be considered as an underlying framework, especially to read the challenges of contemporary definitions of urban life, where the built environment, with all its intangible and tangible forces and networks, is regarded as a continuous field. This approach was initially introduced by James Corner & Stan Allen, but further developed by Keller Easterling in *Extrastatecraft*. She states, “Far from hidden, infrastructure is now the overt point of contact and access between us all, rules governing the space of everyday life” (Easterling, 2014). According to Easterling, understanding the dynamics of cities through "infrastructure spaces" highlights the active operational systems and networks that shape urban and global spaces and challenges conventional understandings of architecture and urbanism (Easterling, 2014). It is possible to emphasize the interconnectedness and networked nature of urban infrastructure by foregrounding the importance of these underlying systems and their broader implications. Easterling's definition highlights the underlying systems that govern urban spaces, such as telecommunications, logistics, and governance protocols. This approach welcomes a “site of multiple, overlapping or nested forms of sovereignty, where domestic and transitional jurisdictions collide” and proposes it as a medium to define these crossroads” (Easterling, 2014). Understanding these forces makes it possible to explore the interactions between technology, society, and urban environments from various disciplinary perspectives. Besides their sociopolitical implications, Easterling points out that interlinked networks that operate across different scales and dimensions shape the physical layout of cities and influence social interactions and economic activities. Affecting urban life by directing capital, goods, and information flows, infrastructure spaces can be understood through a more holistic, forward-thinking approach.

About recent climatic crises that affect society, economy, ecology, geography, and human experience, architecture as a field is tasked with providing resilient solutions to address rapid urbanization, climate degradation, and the swift pace of technological advancements while also challenging established norms and expectations through an interdisciplinary approach (URL-3, 2023). Therefore, incorporating the concept of infrastructure space into architectural design encourages considering broader systems, which define more integrated, resilient, and responsive environments. In this framework, architectural research is expected to employ a multifaceted approach to grasp the intricate interactions central to the economic, political, and ecological dynamics of 21st-century cities.

To understand these redefined urban conditions, it is essential to adopt a holistic perspective that examines the broad associations and relationships within urban environments. This requires reassessing assumptions, strategies, and tactics in urban design, architecture, engineering, and politics. Given that architectural research is intertwined with the current state of cities and the issues of resilience, addressing the complex, unpredictable, and dynamic nature of contemporary urban conditions demands a series of detailed and broad analyses. To deal with the complexity of urban conditions as a learning objective of architectural education, in the 4th year studio in the Architectural Department of TED University, infrastructure space was set as a subject of study. The idea lying behind the introduction of infrastructure space is directly linked to understanding the city's broader dynamics and complex networks of relations. To read, study, interpret, and design infrastructure space, which is shaped by emerging conditions defined by various agents, including human, non-human, international, intergovernmental, and non-governmental entities, “systems thinking” was utilized as a research and design methodology.

The paper argues that this comprehensive approach may define a ground for working with change and dynamism as well as resilience in an urban context through complex design and research processes. With this drive, it discusses how diverse urban conditions are confronted in the design studio, in reference to the notion of infrastructure space as studied in three consecutive years.

Embracing Infrastructure Space in Design Studio through the Methodology of ‘Systems Thinking’

A conscious approach that requires working with multiple perspectives and acknowledging the conditions defined in line with various diverse agencies is hard to achieve, especially in undergraduate education in architecture departments. Embracing infrastructure space in the design studio as a design objective required different methodologies of research and design, as discussed above. Consequently, architects need new tools to develop this kind of research on cities and embrace sources, which may not always be directly from the field of architecture. With this aim, the studio initiated a methodology defined as 'systems thinking', as a novel approach that may be instrumental in considering the overall system together with and other related systems and its discrete parts.

The concept of 'systems thinking' belongs to the field of management, which is discussed in detail by Peter Senge as the fifth discipline. He defines systems thinking as a framework for creating a learning organization where parts interact with each other and build complex systems. According to Peter Senge, systems thinking is "a framework for seeing interrelationships rather than things, for seeing patterns rather than static snapshots. It is a set of general principles spanning fields as diverse as physical and social sciences, engineering, and management" (Senge, 2006). For Senge, 'systems thinking' as a discipline is instrumental for seeing wholes, focusing on inter-relationships rather than things, and patterns rather than static 'snapshots' (Senge, 2006). It defines a cohesive system where different parts, in different scales and with different properties are interrelated with each other to define a complex whole.

This approach offers a deep understanding of complex conditions by recognizing dynamic "behavior that arises from the interaction of a system's agents over time" (Sweeney & Sterman, 2000). It highlights the importance of focusing on relationships instead of outputs and acknowledges nonlinearity and irregularity. With these potentials, systems thinking can be acknowledged as a research and even design methodology for studying structures and understanding system dynamics from different perspectives.

Welcoming collaboration and input, systems thinking as a methodological approach aims to increase the delivery of complexity and hence focuses on defining a complex whole. The idea of 'wholeness' acknowledges that a system consists of various sub-systems, all of which contribute to defining the entire system. For example, according to Ackoff, a system is not the sum of the behaviors of its parts; it is a product of their interactions (Ackoff, 2015). This definition of wholeness as a system facilitates the understanding of complex organizations that function in a dynamic and interconnected manner dynamically and interconnectedly. The concept of wholeness in the systems thinking approach aims to zoom in and out to observe various relationships and interactions, prioritizing the system's dynamics over its outputs. Therefore, acknowledging the systems thinking approach allows focusing on the whole system with a holistic view holistically and requires us to consider each action in the context of the broader systems in which it is embedded (Cavaleri and Sterman, 1997).

Another specific concern of systems thinking is the dynamism of the organization, which demands a specific emphasis on feedback loops rather than the linearity of the process and cause-and-effect relationships. Considering the effects of action not only on the discrete condition isolated from its broader context but also and its influences and effects on other systems alters how the system is envisaged (Senge, 2006). The conceptualization of the system as a 'whole' composed of various complex systems in different scales and compositions allows the redefinition of each sub-system concerning a change defined in another system. This continuous feedback loop within the system also embraces the concept of emergence, where the behavior of the system cannot be predicted only by individual components. This methodology is argued to be entirely in line with the concept of infrastructure space, which was established as a significant component of the design studio. What is argued under the infrastructure space in its relation to systems thinking was highlighted as its potential to orchestrate activities that can remain unstated but are nevertheless consequential (Easterling, 2014).

Adopting systems thinking in the reading, designing, and structuring of contemporary urban conditions was argued to assist the embracing of the urban as an infrastructure space, which may initiate the definition of new opportunities for dealing with the pluralities, contradictions, degradations, complexities, and challenges of 21st-century cities. Therefore, by adopting this methodology, architectural research can consider the broader and long-term implications, focus on interrelationships rather than cause-and-effect relationships, and provide a multi-focal rendering of relations, which define a holistic approach to the design problem and the understanding of infrastructure space in urban scale. Within studio practices, the definition of infrastructure space relates to the concept similar to an operating system, where a series of networks work in association. Going down the path that Stan Allen paved, as deterritorialization of disciplinary striations of the environmental disciplines, like architecture, the design studio practices in these years tried to move away from the design of discrete artifacts to a choreography of multitudinous relations defined under infrastructure space (Allen, 2008).

To gather, interpret, and utilize data from a constantly changing and evolving city and to regard its territory as a field of information, the studio welcomed speculative research tools, which can integrate both qualitative and quantitative data made accessible by technological advancements. Therefore, data visualizations, in particular, were often used to display diverse information and data simultaneously, aligning with systems thinking methodology. As a new challenge for the infrastructure space approach, these multi-layered and multidimensional representations of complex data were utilized to map the ever-changing relationships and expand data of the city in all its aspects, reshaping our understanding, definition, and visualization of urban environments.

Diverse Articulations on the Notion of Infrastructure Space

This method of conducting an in-depth analysis of the city from various scales and perspectives, where multiple systems interact to form a complex whole, offers advantages for embracing complexity in architectural research. Using this framework, this paper presents a selection of student works which were studied in undergraduate architectural design studios at TED University's Department of Architecture in Ankara, Turkey. The semester projects aimed to discuss how the ‘systems thinking’ approach has been adapted to architectural research in studying the urban complexities of contemporary cities, where diverse articulations of infrastructure spaces were introduced as an architectural response to the experienced changes.

As illustrated in the detailed examination of the examples, the systems thinking approach, usually implemented in the first semester of the 4th year, requires students to develop a series of analyses and interpretations of the entire city rather than focusing solely on a specific site. Consequently, the assigned areas for each semester demand unique inquiries that necessitate solutions and design approaches at an urban scale, enabling the conceptualization of the city as an infrastructure space rather than an architectural one. Each example analyzed here was selected from a different semester. Therefore, each example focuses on a different city and includes different infrastructural networks that make up comprise the urban tissue.

Selected cities share the typical quality of being port cities within their regions. Three port cities in different geographies were studied for three consecutive years, one being Beirut in Lebanon, and the other two are from the southern and northern regions of Türkiye, Mersin, and Samsun, both of which are significant port cities of the country. It was aimed to discover the spatial, material, and experiential dispositions along the encounters of water with land/city and develop adaptive, solitary, and resilient strategies for the particular urban context. The utilization of infrastructure and urban space was emphasized in the studio works' research and design processes emphasized the utilization of infrastructure and urban space. All the student groups focus on a different aspect in structuring the basis of their research. However, the main aspect common in all examples lies in their attempt to develop distinct tactics for studying complex urban conditions through infrastructure space and utilize systems thinking to cope with the discovered pluralities and networks of relations. Incorporating systems thinking as an architectural research and design methodology and experimenting with this methodological approach through infrastructure space provided valuable inputs to the studio processes. Through this approach, students studied complex problems that cities face today, generated ideas about rapidly changing cities, and ensured resilient futures for the cities.

Beirut Port as an Infrastructure Space

The cities selected for studio research, Beirut, Mersin, and Samsun, provided comprehensive data to study the urban collapse that the cities faced in the last decades from multiple perspectives and on various scales. In Beirut, issues related to the economy, urban management, transportation, limited access to public and green spaces, and climate risks are just a few problems requiring larger-scale interventions and comprehensive urban strategies. The Beirut Port explosion on August 4th can be seen as a natural outcome of this decline in many respects. The blast created a ground-zero condition at the port area, significantly impacting the land and urban landscape of the waterfront edge (URL-1, 2020). Understanding the specific characteristics of Beirut's urban land, both before and after the explosion, demands a deeper analysis of various aspects of the city on a broader scale. The city's multicultural makeup, historical significance, and regional position are crucial in comprehending and revitalizing Beirut's urban qualities and waterfront urban edge.

Beirut Port is Lebanon's vital economic, strategic, and cultural asset, with significant contributions significantly contributing to trade, employment, and regional connectivity. Facilitating a significant portion of the region's trade, the port is a primary source that supports various industries by providing essential import and export facilities. Being an ancient trading hub, the port has cultural and historical significance in the region, affected by economic, political, and social developments. Because of its connections with multiple modern terminals and its potential as an urban space, the port also acts as an infrastructure space for the city and the Mediterranean region on a larger scale (URL-2). It is related to the networks of the city, where underlying systems of multiple and nested forms operate at various scales and complexities. In this respect, the port is regarded as an infrastructure of the city, and the following student project approaches the networks of relations entrenched by the port (Figure 1).

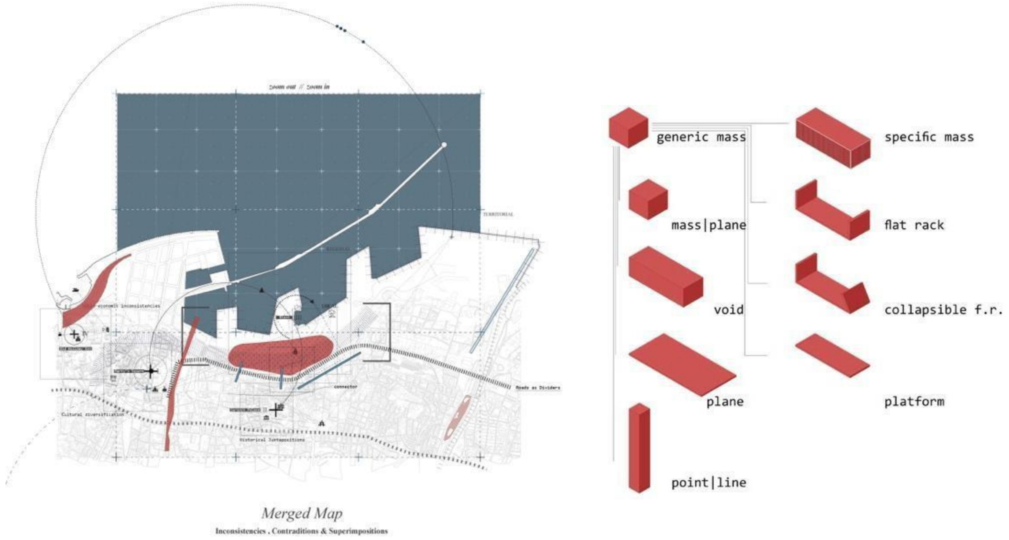

Figure 1: *Research on visible and invisible networks of relations in the port area, Beirut (Authors: Bilgesu Sever, Gökçe Yıldız, Deniz Yeni, Umay Çınar, Ruaa Albasha, TED University, Fall 21-22)*

The harbor area, which controls the geography of the city's northern border along its entire length, is, in fact, a significant factor in determining the city's possible relations with the water. Mapping the inconsistencies, contradictions, and superimpositions, the project tried to discover new territories by overlapping different networks and infrastructures in relation to the port area of Beirut (Figure 1, 2). The research focused on the superimposition of various clusters formed by the intersection of different zones rather than the linear character of the harbor as the result of its operative necessities and questioned how this should be considered a novel input to the design process. In its attempts to unravel how it generates its own infrastructure networks, the research tried to overcome the limitations of conventional maps and plans, as a base.

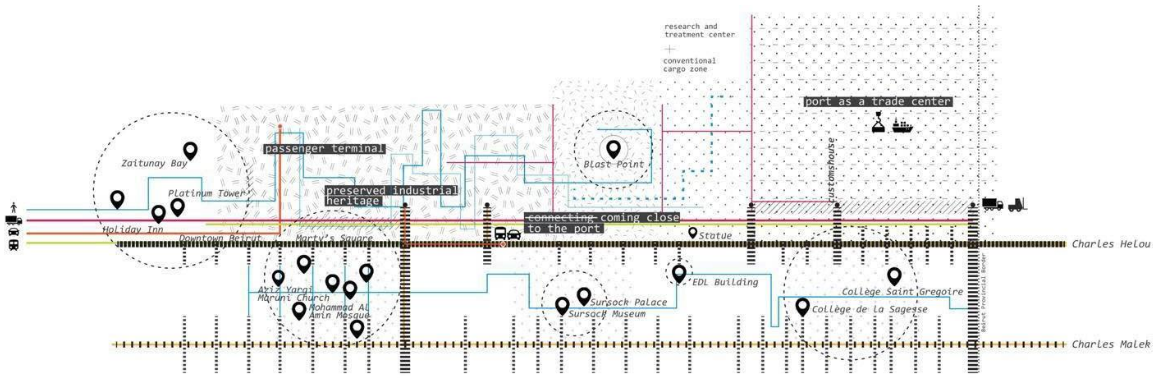

Figure 2: *Mapping the diverse infrastructure space of the port area, Beirut (Authors: Bilgesu Sever, Gökçe Yıldız, Deniz Yeni, Umay Çınar, Ruaa Albasha, TED University, Fall 21-22)*

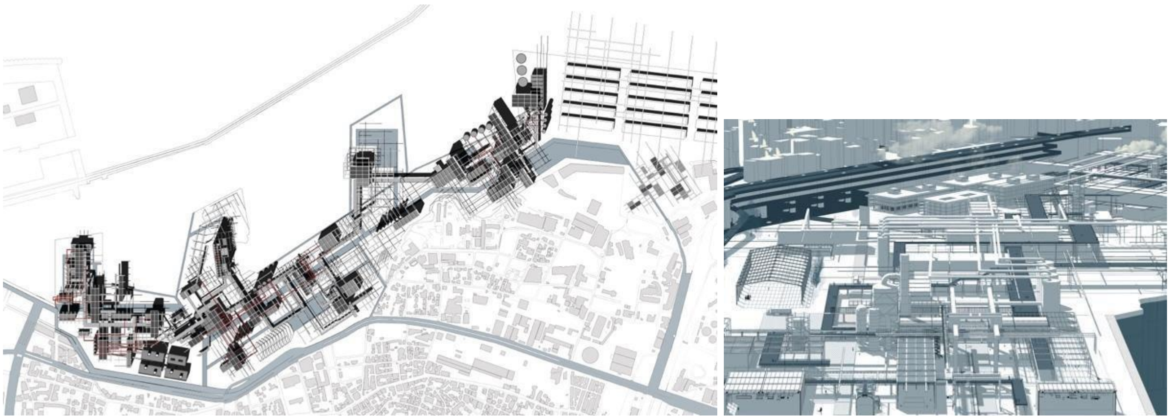

Figure 3: *The design proposal displays the port area as an infrastructure space composed of networks of relations (Authors: Bilgesu Sever, Gökçe Yıldız, Deniz Yeni, Umay Çınar, Ruaa Albasha, TED University, Fall 21-22)*

The design approach of the research benefited from the idea of understanding the operative structure of the port area and initiating a similar design strategy for the whole area. This strategy can adapt to changes easily and interact with others constantly. While proposing a more layered network of relationships, it puts forward the idea that these systems should be considered holistically, functioning and interacting with one another rather than analyzing the infrastructure and superstructures of the port separately (Figures 3, 4). In this scenario, each element constitutes a sub-part of a more extensive operating system, temporarily and permanently decoupled from each other. It can be argued that the correspondence of the research method with the design methodology has led to a more holistic approach to the design process, thus effectively relating the solutions of problems across scales and in the operationalization of systems thinking (Figure 4).

Defining the Infrastructure of Transportation in Mersin

Mersin, a significant port city of Turkey located on the southern coast of the country, is a city that has been developed along the rail line that runs along the east-west axis, connecting the city with other ports and trade centers on the

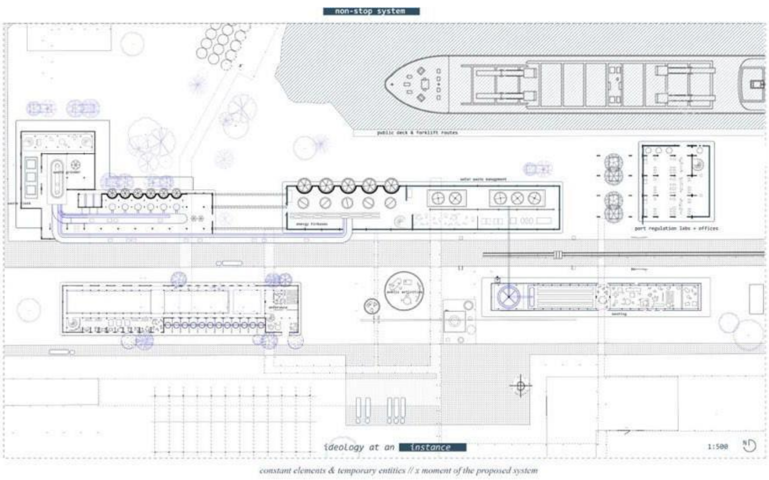

Figure 4: *The design proposal strategies for adapting to change (Authors: Bilgesu Sever, Gökçe Yıldız, Deniz Yeni, Umay Çınar, Ruaa Albasha, TED University, Fall 21-22)*

south coast. In recent years, Mersin has been one of the cities experiencing dramatic transformations, especially in its coastal areas. With its increasing urban problems, it has become the subject of the studio. Despite the port being a critical edge of the city and its development over the years since the 18th century, the growth experienced after the 1960s and the subsequent urban transformation have changed Mersin's urban areas demographically, culturally, politically, and economically. As a result of migration (internal or external), social tensions, infrastructure problems, and urban corruption have become the city's main issues.

One of the unique features of the city of Mersin is the train line between Adana and Mersin, as well as the industrial and educational diversity that has developed due to its use. The train line, considered part of the city's infrastructure, along with a series of associated spaces (port, train station, industrial zone, etc.), forms a complex network of relationships and offers an opportunity to investigate the city's problems and potential. In this context, the project displayed in Figures 5 and 6 aims to overlay data such as the density of the train line, passenger transport rates and schedules, freight transport information, and diversity to question the city's current position and development. Through analyses and visualizations explicitly used to understand the relationship between industry and urban spaces, the train line and its surroundings were considered as infrastructure space and examined through their interaction with the other networks of the city.

The rail line defined and controlled the city's development, industrial and educational spaces, and the most critical transportation axis between the two major cities of southern Turkey: Mersin and Adana. The station and the rail line were discovered to act as the major infrastructural space of the city, together with the port and the industrial facilities that are attached and related to this linear urban structure (Figure 5).

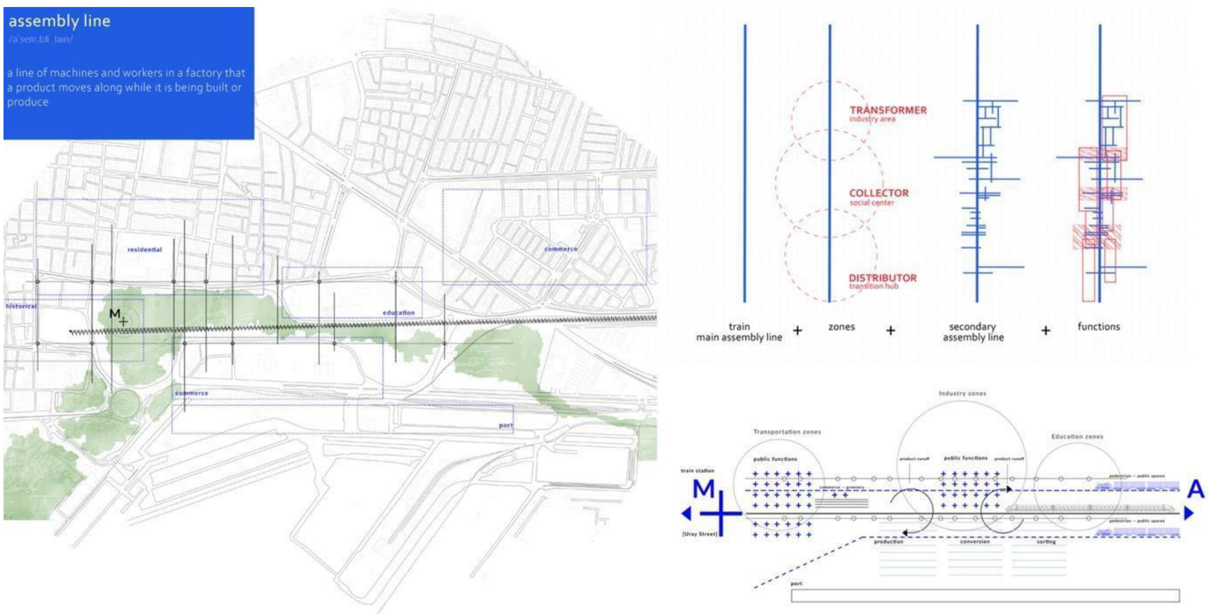

Figure 5: *Rail line as an Assembly line in Mersin (Authors: Rabia Öykü Emiroğlu, Şeyma Dilara Aldemir, Bensu Acarakçay, TED University, Fall 22-23)*

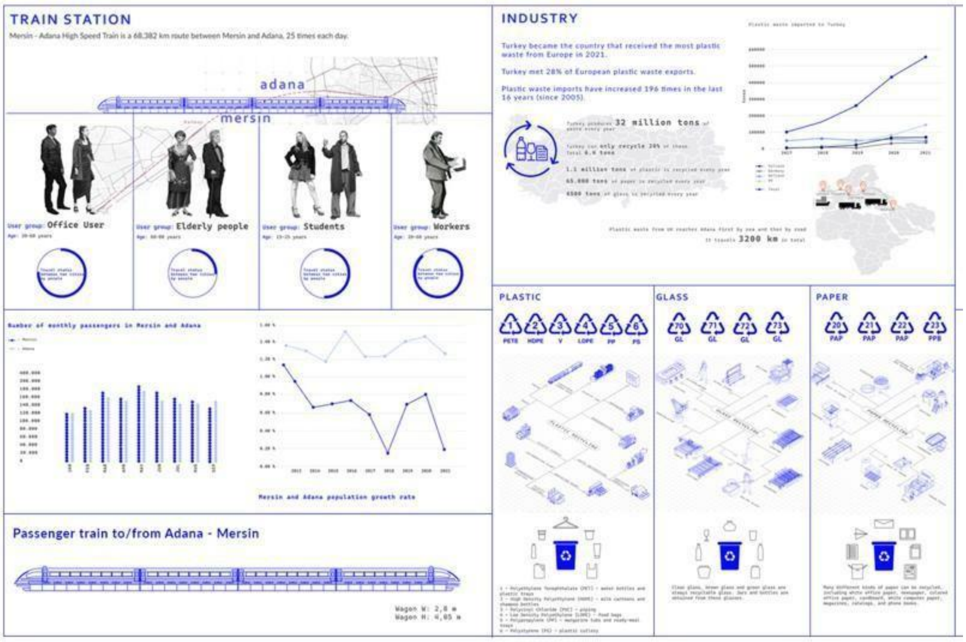

Figure 6: *Analysis of Mersin-Adana rail line (Authors: Rabia Öykü Emiroğlu, Şeyma Dilara Aldemir, Bensu Acarakçay, TED University, Fall 22-23)*

The project provided research, which emphasizes emphasizing the continuous transportation loop /flow of people/goods, etc., between two cities and considers it as a challenge for the city's future urban development. Focusing on the potential of this investigated linear axis not only as a transport axis but also on its potential to host many different activities on and around it; the project adopted the approach that this urban infrastructure space could be regarded also as an urban assembly line. The research process revealed the potential of this infrastructural line as a space where multiple conditions can overlap and even emerge as a new hinterland that can host new urban interactions (Figure 5).

By studying the line quality and accompanying urban spaces, the project proposes that the line can be acknowledged as an infrastructural link between industrial facilities supporting the industrial potential of two cities. The environmental conditions, for example, the central role of Adana in collecting and transferring global garbage/waste, were regarded as an industrial input, which can assist the exploitation of the rail line as an infrastructural urban interface (Figure 6). In line with the research findings, the project developed a scenario that connects the garbage /waste transfer from different parts of the world through Adana and how the linear infrastructure can turn into an operative line for recycling and upcycling the accumulated waste and managing its transfer to other countries through the Mersin port (Figure 7).

The project approached the definition of the infrastructure space in the city of of Mersin by integrating the recycling, rail station, rail line, and industrial zone. This integration is argued to enable the creation of an industrial network that supports the city's urban development. Conversely, the recycling industry, in conjunction with the port, rail station, rail line, and industrial zone, which are defined as the infrastructural space of the city, amplified urban networks, proposed new urban scenarios, and extended the lands of coexistence. Consequently, the project embraced a systems thinking approach and defined the infrastructural space to study local, trans-local, and global occurrences in a contemporary industrialized city, Mersin.

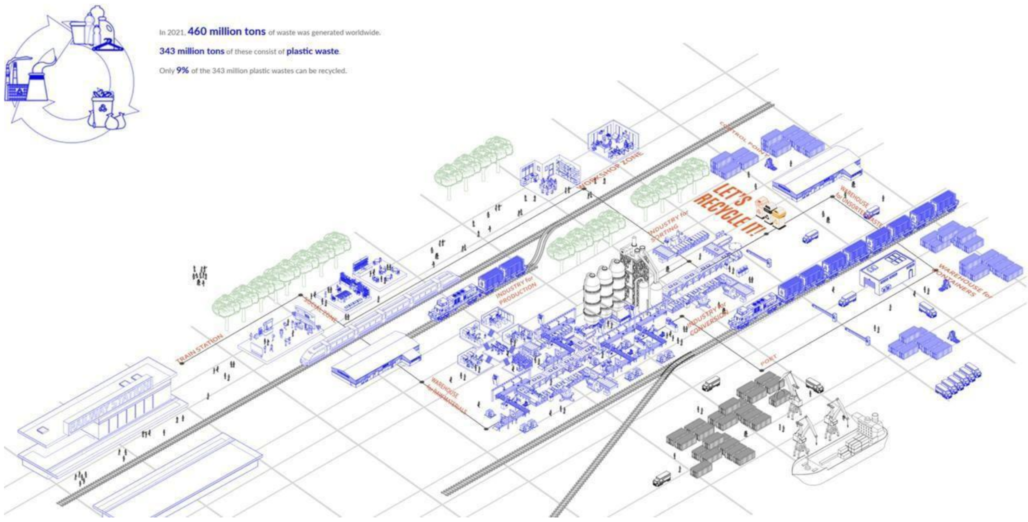

Figure 7: *The industrial network proposing unilinear assembly for cycling waste (Authors: Rabia Öykü Emiroğlu, Şeyma Dilara Aldemir, Bensu Acarakçay, TED University, Fall 22-23)*

Wetland as the Infrastructure Space of Samsun

Samsun, another industrial port city on Turkey's northern coast with infrastructure characteristics similar to Mersin, has been dealing with the consequences of urban challenges that have emerged over the past decades, altering its social, geopolitical, environmental, and architectural conditions. Recognized as a transportation and industrial hub in the northern region, Samsun is connected to the Black Sea region of Anatolia through various routes. For years, the city has managed national and international trade routes and has been promoted as an industrial and agricultural center that strengthens its geopolitical and geomorphological position in the region. However, in recent decades, environmental degradation, urban decay, and industrial policies have significantly changed the city's urban conditions and definition.

The project aims to analyze the city on a large scale, considering its geological and climatic characteristics. It has defined a water formation library for the city, as presented in Figure 8. Within this scope, the project can be seen as a reading that defines the relationship between the city of Samsun and water by analyzing the water patterns of different cities and mapping the potential formation of water movements. The project addresses the Mert Stream, which has lost its wetland characteristics due to uncontrolled uses, and its surroundings as an infrastructure space, aiming to conceive the stream as part of a large-scale infrastructure network. To propose a new network, creating a comprehensive library that maps and compares existing water patterns from various cities allows for developing various water management tactics and guidance in the design. The information obtained and collectively mapped, rather than individually, opens up the possibility of new data relationships that may not be perceived when analyzed independently (Figure 8).

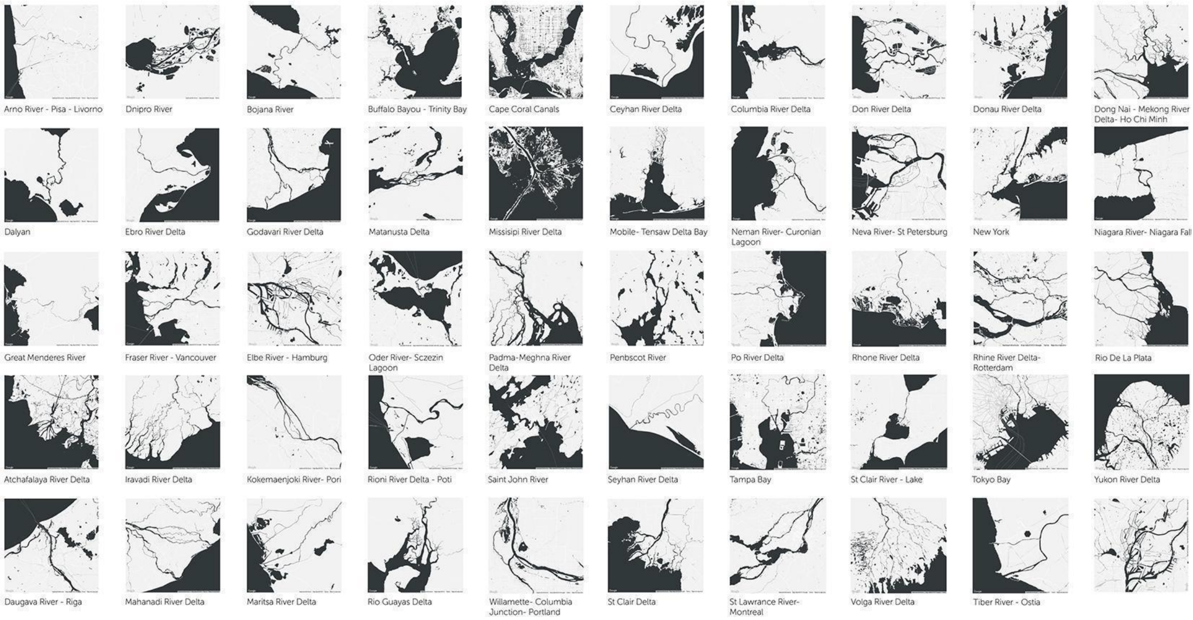

Figure 8: *A library of water-land relations. (Authors: Bartu Aydınlı, İlayda Ülgen, Zeynep Süner, TED University, Fall 23-24)*

The Mert River, flowing through the city center, has been re-envisioned as a fundamental infrastructural element that not only delineates but actively shapes the urban and industrial conditions of the city. Historically, the river has been pushed to the periphery as urban development prioritized separating the industrial zone from residential areas. This shift has relegated the river to a mere boundary rather than an integral component of the cityscape. The project seeks to rectify this oversight by treating the river as a pivotal zone with extensive physical, ecological, and biodiversity value capable of addressing various emerging crises within the city. The project adopts a comprehensive approach by analyzing the river and the broader regional water resources, including flood patterns and environmental changes. This analysis reveals that the river's current state results from uncontrolled developments and neglect, which has led to its diminished role in the urban environment. By mapping these conditions, the project highlights the need to reconceptualize the river as a waterscape and a vital infrastructure space that can enhance the city's resilience.

To address these issues, the project proposes the establishment of a water treatment zone along the river. This zone will manage and process waste from residential and industrial zones, thus mitigating pollution and improving water quality (Figure 9). Additionally, the project envisions the development of alternative waterways to manage flood risks more effectively. By expanding the riverbeds to their original dimensions and introducing new channels, the project aims to adapt to varying water levels and mitigate the impact of floods in different seasons (Figure 10). The plan also includes the creation of a lagoon and several islands that will serve multiple urban functions. These new spaces will integrate residential, recreational, educational, and industrial activities with this newly formed wetland. This integration will redefine the relationship between the urban fabric and the river, creating dynamic spaces and a network of relations that respond to the river's changing states.

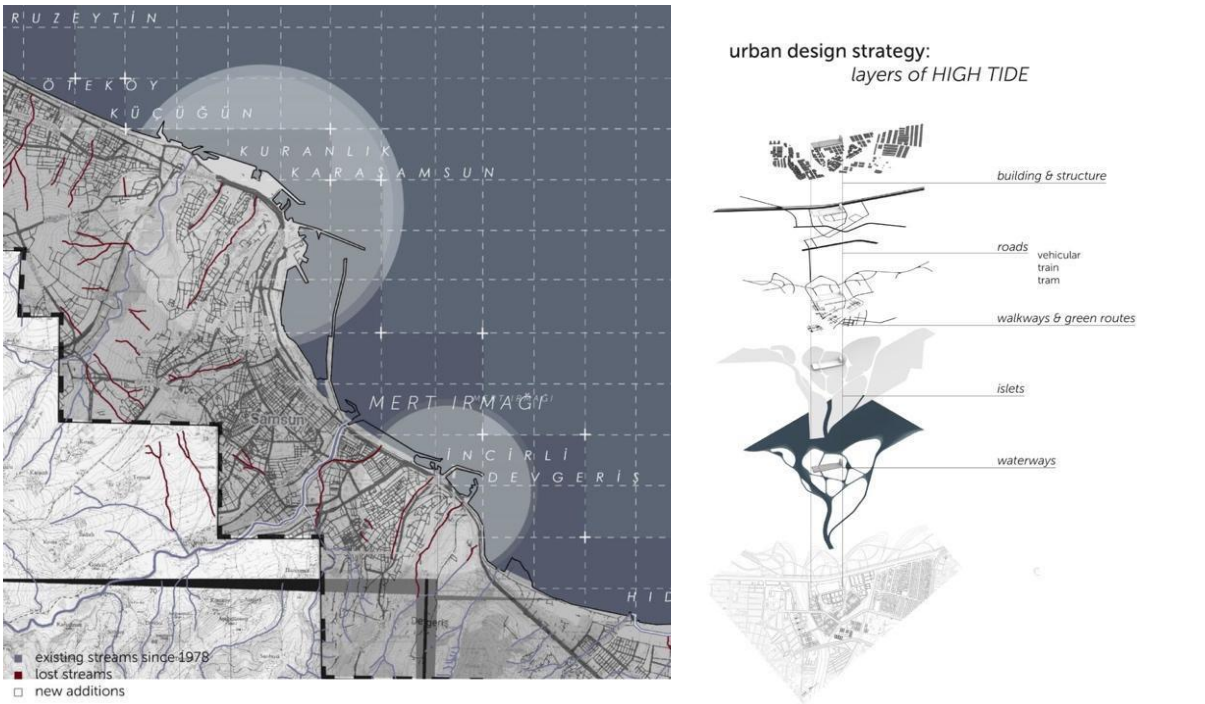

Figure 9: *Analysis of water zones and changing patterns within the urban tissue (Authors: Bartu Aydınlı, İlayda Ülgen, Zeynep Süner, TED University, Fall 23-24)*

All the selected examples emphasize the interrelations in the city and reveal the complex conditions where various layers of data were overlapped and reinterpreted. In the studio process, the data visualizations also create another data set that contributes to the studio's learning environment. Each visualization provides a different perspective on the city's urban conditions and initiates the reading of visible and invisible states particular to the studied geography. By exposing the diverse networks of the city, these complex visualizations were utilized in the studio process to understand how these networks work and affect one another. Although the paper includes selected examples from studio productions, the visual palette of data sets

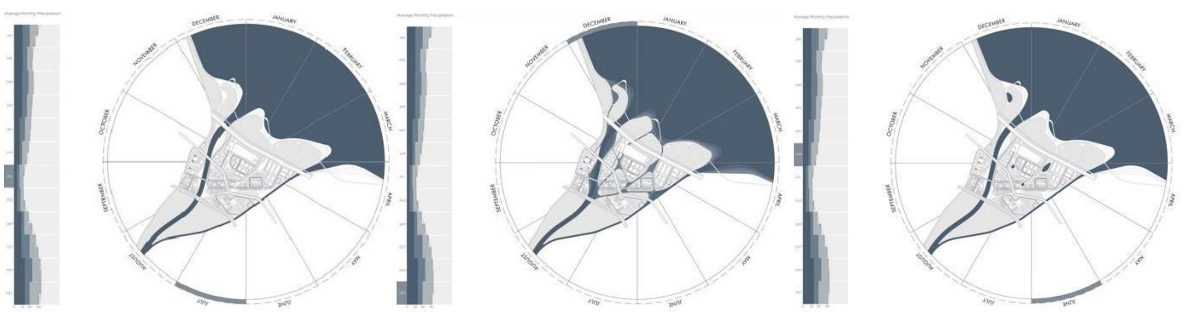

Figure 10: *Design proposal adopting to change of water levels and infrastructure of wetland created by Mert Stream in different months of the year (Authors: Bartu Aydınlı, İlayda Ülgen, Zeynep Süner, TED University, Fall 23-24)*

defines an explorative ground for architectural research and design.

Conclusion

Regardless of their subject of analysis, all the examples discussed here try to unfold the visible or invisible transformations of the cities initiated by social, economic, and often political concerns. It aims to make the unknown urban networks more comprehensible and integrate them into design processes in architectural education to define an alternative methodological approach that can be used to study complex urban design problems. In that respect, the 'systems thinking' approach adapted from a transdisciplinary field provided positive input in the design studio processes, where the students have a chance to can work within non-linear and complex design processes. With this new methodological input, it was possible to overcome the shortage of already experienced and practiced design methodologies for dealing with the difficulties of large-scale urban design problems. The aim has never been to propose a uniform urban analysis or design method, or to recommend the use of using systems thinking in all urban research and design studios regardless of the context. Of course, since all sample projects are the products of undergraduate studios, the research processes and transferring the research output to design cannot be as detailed and comprehensive as the outputs of a master's studio. However, it has nevertheless been a method with many gains in terms of determining the framework of perception and research on the urban scale and understanding the city together with all the systems that make it exist.

As discussed in the article, systems thinking, in that sense, offers new ways to engage with urban complexities and provides more open-ended, flexible research and design processes compared to traditional methods and it also enables the consideration of the urban field as an infrastructure space. Concerning the discussion opened up by Easterling, the infrastructure space is believed to offer means of amplifying urban networks, proposing new urban deals/scenarios, and extending the lands coexistence. Therefore, it can be embraced local, trans-local, and global occurrences in contemporary industrialized territories (Easterling, 2014). It can be argued that the increasing urban complexity, as demonstrated through various scales and types of infrastructure definitions and spaces, has created a productive discussion platform within the studio. The utilization of systems thinking as a methodology also supported the understanding of the changing conditions of cities and their quantitative/qualitative components, creating a solid ground for responding to the network of relationships that structure the essence of the contemporary city, along with all its climatic, environmental, political, and social issues. As Senge states, "Systems thinking is a conceptual framework, a body of knowledge and tools developed over the last fifty years to help us see patterns more clearly and understand how to change them effectively" (Senge, 2006).

Considering the future roles of architecture and architectural research, ensuring urban resilience is perhaps at the forefront of all discussions. Expanding the field of architectural research and integrating various data and inputs are crucial for developing ecological approaches and creating a more sustainable future. In this context, regarding the city as an infrastructure space supported by the idea of systems thinking forms the basis for discussions on its potential ground-breaking roles in architectural design education and architectural research processes.

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Artificial Intelligence as a Pedagogical Tool for Architectural Design Education

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Abstract: Artificial intelligence (AI) is increasingly influencing art and design, with tools like ChatGPT, DALL.E, and Midjourney transforming the way designers create visual content from written descriptions. Since its launch, AI-powered systems have sparked widespread interest and expanded production practices in design and artistic creativity. This transition has ushered in a new era of co-authorship, in which human designers and AI systems collaborate to reshape the boundaries of design. The introduction of language-based diffusion models has enabled a harmonic integration of language and visual elements, resulting in creative design paradigms. However, this incorporation of AI raises serious concerns about the cultural and social relevance of AI-generated designs, which may become estranged from human contexts if heavily dependent on algorithms. The representation of architectural knowledge is also evolving, as AI allows for a return to textual and mathematical tools, rather than traditional visual representation methods. This transition creates substantial challenges and possibilities for architectural education, particularly in design studios. The integration of AI into design curricula has the potential to reshape architectural education, necessitating that educators adapt to technology advances. This study investigates these developments, providing insights into the evolving landscape of design pedagogy in the age of AI and contributing to the continuing debate about the role of AI in design and architecture.

Keywords: Architectural education, Artificial intelligence, Design learning, Design studio.

Introduction

Machine Learning (ML) has become more prevalent in our daily lives, leading to a growing interest in art and design, as well as Artificial Intelligence (AI). These applications, which make communication between ML and humans possible by eliminating the prerequisite for software knowledge, are pushing the boundaries of creativity and technological interactions by transforming textual descriptions from users and/or images that indicate contextual situations into customized visual content. While the language-based pre-trained models ChatGPT-3 will be publicly accessible by the end of 2022, to anyone with literacy and access to technology; the AI-powered systems DALL.E and MidJourney—which both provide customized visual content—have sparked interest in the fields of art and design and have begun the process of transforming design from a human monopoly into a joint product of artificial and human beings.

In this new approach, which emerged as a result of language-based diffusion models, designers are exploring a new design process in which language and visuals contribute together, while architects and architecture students want to learn what these new systems can offer them. In this perspective, it is clear that the interaction between architectural design processes and artificial intelligence is becoming a topic for discussion among practitioners and academics (Leach, 2022; Ploennigs & Berger, 2023). While artificial intelligence (AI) provides architects with new conceptual frameworks and performance-enhancing tools (Zhang et al., 2023), it also highlights the relationships that architecture students currently have and will have with AI. Considering the integration of this new link between architecture students and AI into traditional pedagogies, a problematic and complicated scenario is given in the context of architectural design pedagogies.

The foundation of architectural design education is the dissemination of architectural knowledge, which is primarily developed within the boundaries of the design studio, through hands-on activities emphasizing the experience of design-making within relationships established with peers and master-apprentices, and through oral discussions that primarily use visual aids. The traditional educational environment is undergoing changes due to the rapid changes brought about by digitalization in design processes. As a result, a major concern is how to effectively implement established pedagogical paradigms that prioritize the transmission of architectural knowledge in the design studio (Yıldırım, 2023a). This study aims to critically examine the transformative impact of innovative digital design tools, which are envisioned to be indispensable for today's architectural practices, on the culture of architectural representation, and to focus on the various openings of the use of artificial intelligence, which has begun to be encountered as a new tool while examining contemporary architectural design studios, as a pedagogical tool that affects architectural design education.

While the architectural profession can swiftly adjust to current technological breakthroughs and incorporate digital tools into its practice, the gap between the skills taught in the classroom and the competencies necessary in professional practice is rapidly widening. This mismatch is not only a technical flaw or an isolated case that may be avoided by adding a skill set to the curriculum that can be completed by falling behind, but it also results in inconsistency between the skills taught in academics and the skills required in practice (Abdullah & Hassnpour, 2021; Hariri et al., 2020), it also undermines the primary goals of architectural education. This paper argues that integrating digital literacy into architectural education is not a practical necessity, but rather a pedagogical imperative that enriches teaching and learning experiences and suggests ways in which architecture can combine methods used by other design disciplines with its own.

Transfer of Architectural Knowledge - Architecture, Design and Artificial Intelligence

Text-based representations used by ancient Greek architects, one-to-one scale models based on geometric relationships used by medieval builders, perspective drawings developed by Brunelleschi and widely used during the Renaissance, and the introduction of Cartesian geometry with Beaux-Art in the late 18th century, have all been adopted as a more standardized common architectural language, especially in the last few centuries, and have evolved into widely used conventional (Carpo, 2003; Hewitt, 1985; Necipoğlu-Kafadar, 1986). The transition from manual to digital tools in architectural production, which adopted a Cartesian geometric approach, particularly with the introduction of Computer Aided Design (CAD) in the 1980s, is more than a simple transformation. The CAD-led digital revolution has also caused a paradigm shift in how architects approach design and engineering, necessitating a rethinking of the integration of technology, pedagogy, and content in architectural education (Burry, 2014; Carpo, 2012; Dearden, 2006; Oxman, 2006). Building Information Modeling (BIM) software, which followed CAD in the 1990s, enabled the construction and maintenance of three-dimensional, real-time design models, allowing architects to visualize, simulate, analyze, and collaborate in new ways (Aish, 2013; Karakaya & Demirkan, 2015). The wave of parametric design, which swept the world in the early 2000s with its highly stylized approaches and pushed the known limits of Cartesian geometry by allowing the exploration and manipulation of complex geometries via algorithms, emerged as a computational design method distinct from CAD and ICT (Kolarevic, 2013; Oxman, 2017; Schumacher, 2011).

Unlike its predecessors, parametric design is more than just a tool for designing complex geometries; it also opens up fresh prospects for multidisciplinary collaboration with fields such as mathematics, computer science, and biology. Parametric design also introduces a new level of complexity into architectural design education, requiring a shift from an intuitive pedagogical approach to a more analytical and computational approach, which enriches the architectural design process and has prompted a rethinking of architectural education by broadening its scope (Oxman, 2006; Radziszewski & Cudzik, 2019). Integrating these new computational pedagogies with traditional architectural pedagogies creates a program that can address the intricacies of computational design (Mark et al., 2008), and the requirement for educators to continually enhance their skills in order to stay up with fast evolving technologies (Tucker-Raymond et al., 2021). Although this trend tends to embrace, or at least not oppose, novel design approaches, it is not very favorable for architectural education, which also values the transmission of professional practices. Educators have been responsible for incorporating computational design into architectural design studios, often through elective courses and graduate education (Uncu & Çağdaş, 2022).

While discussions on the professional applications of computational design and its proliferation in design education proceed, the applications of artificial intelligence, which are now increasingly widely available, have created new opportunities in a variety of fields, including art and design. By adapting to the multidisciplinary nature of architectural practices, they can serve as an unique tool for automating design tasks, topology optimization, energy efficiency, material use, and construction processes, particularly parametric design and design tasks involving large datasets with complex operations (Gero, 2012; Yıldırım, 2023b). The interaction of artificial intelligence with architecture is transforming not just architectural design services, but also the products. It indirectly reshapes social and cultural structures by making transdisciplinary design products accessible to the general public via buildings that contain systems that learn from user experience, such as smart buildings and customizable spaces (Şapcı & Pektaş, 2021).

In light of these advancements, researchers in the field of architecture are investigating whether artificial intelligence can show competence in architecture if it is trained by introducing the problem-solving techniques used by architects during the design process (Başarır & Erol, 2021). Burry (2011) thinks that the competence and tacit knowledge that designers acquire via experience are internalized and transformed over time into transferable knowledge that can be quantified and reproduced using digital tools. He mentions that data collected utilizing digital instruments, particularly in the built environment, can provide more objective measurements/evaluations. According to Leach (2018), the subjectivity of artificial intelligence based on information obtained from the built environment allows for a more objective evaluation than subjectivity that varies according to the architect's interpretation, enabling other actors to create design impact scenarios with greater accuracy, making the use of artificial intelligence in the field of architectural engineering explorable. Artificial intelligence systems, thanks to their algorithms fed by complex data sets that are difficult for humans to address, enable architects and other building stakeholders to effortlessly create potential impact scenarios that will be caused by design (Leach, 2018).

Opinions on Artificial Intelligence and Architecture Education

Artificial intelligence-driven discussions and transformations have a direct impact on architecture education. Design students, who have started to discover the uses of artificial intelligence in many areas of daily life, as well as the conveniences offered by emerging technology, seek to incorporate these next-generation digital tools into their creative processes. In this context, it is critical to consider how, at which stages, and under which identities artificial intelligence will be used in architectural education. Oxman (2008) investigated the extent to which architecture students incorporate innovative design approaches into their conceptual design processes and discovered that parametric formalisms, one of the current approaches, have started to be incorporated into students' conceptual approaches, but artificial intelligence tools such as machine learning are seldom used in conceptual design. It is believed that there is a link between the slow progress of incorporating AI into the architectural education curriculum and the studio instructors, who are not in short supply, who oppose the use of CAD programs in conceptual design on the grounds that it will dull skills in analog design and representation methods (Billie, 2002).

Contrary to what is suggested by studio directors who resist the use of digital methods in conceptual processes with these ideas, the use of digital tools in conceptual design, beyond the search for alternative side paths carried out only in digital media by excluding all other tools, can be presented in a hybrid structure that allows the permeability of analog and digital, and can create a broader set of tools that the student can include at the stage he or she deems appropriate (Salman et al., 2008). Although not as conservative as architecture professors are resistant to digital culture Picon (2011) notes that using digital tools in design can lead to designs disconnected from human and context. This situation may arise, especially when students with limited architectural knowledge allocate design processes to artificial intelligence algorithms in the pursuit of innovative design without first establishing the relationship between design, user, and context in conceptual design and early design processes. However, a master architect-educator can help to bridge the gap between novice architecture students and artificial intelligence, which is still in its early stages, and prepare a base for a controlled discovery.

The number of academics researching the integration of artificial intelligence into design and design education is escalating. By instrumentalizing the design narrative, which is frequently used in the conceptual design phase in design courses by academics working in this direction, there are studies on basic conceptual productions and form finding studies on images using language-based artificial intelligence systems in students' design processes (Ploennigs & Berger, 2023; Sadek, 2023). These experiments consist of both text-based, text plus image-based, and solely image-based outputs generated with artificial intelligence.

Ploennigs and Berger (2023) investigated architecture students' creative form-finding processes utilizing texts prepared via the architectural storytelling method, as well as the effect of artificial intelligence on the form-finding processes of groups that used and did not use AI. It was discovered that the group employing artificial intelligence made partial choices from the images generated by artificial intelligence and used them in a way that had a positive impact on their form-finding processes. Although both groups prepared scenarios, it turned out that students in the group utilizing artificial intelligence encountered unusual forms in their productions. In this context, the potential for implementing artificial intelligence as a tool to promote creative design comes to the surface.

Smith et al. (2023) stated that there may be scenarios in which artificial intelligence does not always give outcomes that are suited for real-world applications as a consequence of their AI studies with textual definitions. Within the scope of the study, it has been discovered that the images produced by artificial intelligence via keywords entered to be used in conceptual approach and form generation are either a composition in which images associated with keywords are superficially brought together, or that some keywords are selected by artificial intelligence while others are ignored. In fact, this circumstance is similar to the methods that produce speculative designs by focusing on parts used in early design processes, and in some ways, it highlights the parallels between human and artificial beings in terms of design methods. Although the designs generated via artificial intelligence in conceptual design and form finding processes do not produce results that are in line with the initial objectives, they can be seen as an intermediate step that can be interpreted by humans and incorporated into the process (Smith et al., 2023).

Yurman and Reddy (2022) used artificial intelligence to generate reproductions of the objects they painted with watercolor method in a study employing just visual material rather than text. They both created a watercolor painting of a tangible object, handed it to each other, and made reproductions. The reproduction was then returned to the original maker, and a creative transformative process was carried out by reproducing reproduction of the reproduction. In the study's continuation, a new set of reproductions was generated by repeating the initial producer-artificial intelligence-second person cycle while incorporating artificial intelligence as a creative participant. As a result of this study, it has been observed that the ambiguity brought by the watercolor technique leads to new visions for both human and artificial intelligence, but in the reproductions in the human-AI sequence, the artificial intelligence creates dramatic new visions every time, while in the reproductions in the artificial intelligence-human sequence, the human tends to imitate the artificial intelligence product at a high rate. Although the study was not conducted in the context of architecture, the processes for generating visuals from visuals, particularly in design, and humans' tendency to imitate and make sense of artificial intelligence production are similar to the speculative work done by students who want to use artificial intelligence in design studios today with sketches or models. Especially in architectural image production, visual-based artificial intelligence software frequently exhibit dramatic changes depending on the ambiguity of the given image.

Studies on the simultaneous use of visual media and text input in generative artificial intelligence systems, as opposed to text-only or visual-only inputs, are not uncommon (Gal et al., 2022; Gao et al., 2022; Zhang et al., 2023). In the study carried out by Zhang et al. (2023), the sketches produced on the digital tablet were uploaded to the artificial generative artificial intelligence system, and the artificial intelligence was made to produce visuals by making a description over the text and using the sketches, after that the designers made a layered sketch study over the visual alternatives produced by the artificial intelligence. The original sketch and new layers were re-uploaded to the artificial intelligence, and new variations were generated by describing them again. The participants in this study are professional architects. As a result, experienced architects were able to work with clarity in both the visualization and written explanation of design ideas, as well as to expertly apply the seeing-knowing-interpreting procedures to the interplay of design elements. As a result, they avoided leaving ambiguous areas that could lead to artificial intelligence producing irrelevant results, allowing them to employ it for its original purpose.

However, because architect candidates at the learning stage are not mature enough in terms of seeing-as, seeing-that, and design knowledge, they can present very vague details to artificial intelligence at initial stages, when describing in written and/or visual form. In fact, trainable artificial intelligence systems that use a feedback mechanism function as rookie systems alongside these rookie designers, leaving the student with even more ambiguous outcomes. Based on the examples analyzed, we can see that the work produced by artificial intelligence using text, visual, or hybrid data inputs has parallels with the processes of seeing, making, and designing loops, as well as the revision methods used in the design studio as described by Schön (1983).

In the design studio, students sketch design concepts based on a written or oral recipe. In these studies, students show their work to their teachers at regular intervals and solicit their feedback. Depending on the instructor's inclination, this exchange of ideas can be continued solely through verbal communication, or it can be extended both orally and by sketching on each other's drawings, which are usually layered over the sketches at the desk. Schön (1985) defines this process, which develops naturally in this design studio, as a reflective pedagogical approach. The instructor, who acquires knowledge about the design from the students' sketches and oral narratives, interprets his or her own ideas through oral narratives and visual representations; however, despite all of these interpretations, the student is expected to develop the design using the instructors' interpretations. This communication takes place in an environment where all studio participants can observe and intervene, and students' progress in their individual projects by learning from each other's design ideas as well as the revision process between other students and the instructor. Therefore, the student refines the design project by adding his or her own intellectual process and observational learning to the instructor's recommendations, developing a fresh interpretation. It is considered that learning occurs in this manner in the design studio, based on the master-apprentice relationship (Goldschmidt, 2002; Schön, 1985; Uluoğlu, 1996).

Changing pedagogical identities in the design studio over time has transformed the instructor from a coach who imposes design orientations to a coach who accompanies, supports and facilitates learning (Dutton, 1991; Ledewitz, 1985; Lee, 2014). This, in fact, has enabled cyclical interpretations in design learning processes and opened up space for new breaths that the relationships established between student-instructor, student-student and student-instrument can bring to design. In today's architectural education environment, with digitalization and especially the use of artificial intelligence technologies, there are studies that draw attention to the necessity of the current studio order to rapidly integrate artificial intelligence into studio pedagogies (Kavakoglu et al., 2022; Ogata & Ogawa, 2023; Tianran et al., 2022). Just as previous digital tools were used as tools over time and then turned into environments where the design process was carried out and became an integral part of architectural education, the researchers also mention the possibility of artificial intelligence being first a tool and then an environment in which design will be done (Schmitt, 1997). Although the use of artificial intelligence in the field of design education is discussed at the graduate level within the framework of didactic and constructivist theories, there are researchers who suggest that it should be used as a tool rather than collaborative in terms of project-based learning pedagogies at the undergraduate level (Khean et al., 2018; McCormack et al., 2020). However, Başarır (2022) underlines that if artificial intelligence is seen as a learning machine, it may be possible for it to gradually acquire profession-specific knowledge. In this case, artificial intelligence has the potential to be both a guide for design students to acquire professional knowledge and a partner to accompany their design processes. Kavakoglu et al. (2022) conducted a study with students in the early stages of design education, they examined the effect of artificial intelligence on creativity and observed that datasets created in collaboration between students and artificial intelligence encouraged creativity.

Epilogue

The applications of artificial intelligence in architectural education raise debates at different levels in terms of conceptual approaches, alternative approaches and collaborative approaches. From a conceptual perspective, although artificial intelligence offers students a new medium to open the doors of creativity, students are not equipped to use artificial intelligence in a targeted manner because they lack sufficient knowledge about the competencies and limits of artificial intelligence (Flechtner & Stankowski, 2023). In today's architectural landscape, students use artificial intelligence in architectural concept development through visual synthesis. Thanks to visual synthesis, 2D images and 3D models can be created quickly and easily using text and images. However, it may not be easy for students to use these systems properly. They consider artificial intelligence as a joker who can do anything in almost every situation, with unclear and unsteady directions that are not intended. However, artificial intelligence provides unpredictable outputs in images based on poorly defined data. Students exposed to a series of random results search for meaning in the ambiguous contents of the image pool, but frequently fail to locate it. In this case, the series of images exposed are processed in the students' memories within the context of today's youth's media consumption habits, and they take their place among the consumed images that they look at superficially but do not see, far from examination and internalization on a scroll-and-pass basis.

In terms of alternative approaches, artificial intelligence systems can be employed not just for visual synthesis, but also for massing decisions, form finding, and optimization. The use of parametric design tools, interactive evolutionary computation, and genetic algorithms can help architects create novel and imaginative designs (Castro Pena et al., 2021; Ekici et al., 2019). In order to prepare students for professional practice, the use of artificial intelligence starting from the early design period can create more efficient designs in terms of sustainability. In addition, topology optimizations used for structural design provide opportunities for architecture students to improve themselves and their designs in structural design, which is often a weakness of architecture students. The processing of all these possibilities, which are envisaged to contribute positively to design and design learning processes, in design studios draws attention to a different issue with deeper implications.

First and foremost, these alternative techniques can only be included in design studios on a project-by-project basis; because different projects and levels have varied requirements, it is unrealistic to expect all alternative approaches to be included within the scope of each project. Second, for students to be able to apply these other ways, they must be introduced to and given access to them, which is a problem with its own sub-expansions. Students should be exposed to artificial intelligence systems with alternative uses during their education. Furthermore, theory should be supported with practice through integrating it partially into the design studio structure. Another consideration is that students must be technologically literate in order to make use of these artificial intelligence programs (Kee et al., 2024). However, in order to achieve creative results with the appropriate method, students must first acquire a precise language for communicating with artificial intelligence. To create this language, they need to be familiar with the basic machine learning language vocabulary. Since many students lack this vocabulary, the aforementioned ambiguity arises and students do not use these alternative approaches with their existing knowledge, no matter how enthusiastic they may be. At this point, as for students to be able to use AI as a design tool that enables alternative approaches, it is necessary to have a basic education in computational systems (Hardman, 2022). Due to the already dense and loaded content of this basic education, there is no room for maneuver for its inclusion in the architectural curriculum. In this case, the actors of architectural education are expected to undertake this task in order to transfer these alternative approaches to students. However, not every design educator is expected to take on this role due to both changing areas of specialization and changing levels of digital literacy and competence. Therefore, although the use of these alternative approaches is partially left to the design studio instructors, it generally creates a situation in which the student can progress with his/her own efforts and is relatively isolated.

Finally, the ethical implications of using artificial intelligence in design and learning processes must be carefully considered. The integration of artificial intelligence into design education raises ethical concerns in multiple areas. First and foremost, the widespread use of artificial intelligence drastically reduces data privacy (Jaime et al., 2023). Many AI tools store the data given to them in an open-ended common repository that they utilize to generate responses for all system users, not just those that share data, and there is no mechanism to access this stored information. A second ethical dilemma highlighted by these open-ended systems is the issue of ownership. The division of ownership between the designer and the artificial intelligence in a product generated with artificial intelligence poses a problem (Crawford et al., 2023). Design students should be encouraged to employ artificial intelligence with caution considering data privacy and ownership concerns. Finally, unfortunately, today, not all students have equal opportunities for education and differences in access to technology are frequently encountered. In this respect, the use of artificial intelligence and technology in terms of equality in education points to a problematic area in terms of integration into compulsory education when access concerns are considered.

As the practice of architecture has adapted to rapid digital transformations, it has directly affected the architectural design studio. This transformation in practice has the potential to lead to changes in pedagogical paradigms, learning outcomes and even the culture of architectural design education. This article draws on the gaps in the literature to provide indications that artificial intelligence is an inevitable revolution in architectural practice and education, as it was in the digital revolution and paradigm-shifting CAD and computational design that preceded it. It is also mentioned that these innovative design tools have a transformative effect on the conventional architectural representation culture, which is predominantly based on visual media production, in a way that textual representation gains weight not only in informal communication but also in formal communication, and its impact on design exercises with artificial intelligence is emphasized. In this context, it is seen that the reflections of the change in the culture of representation are also affecting design studio pedagogies. In particular, the limiting and enriching effects of design studio instructors' competencies in new digital tools, which play an important role in the field, on design pedagogy are presented and the importance of digital literacy of both students and instructors in terms of incorporating artificial intelligence into design processes is emphasized. While the dangers of the uncontrolled use of artificial intelligence as a wild card in the current order by architectural students are highlighted, it is predicted that its competent use will improve the quality of architectural education and prepare students for the equipment expected from them in the post-graduation architectural environment by stepping in at the point of closing the gaps.

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Bibliometric Analysis on Artificial Intelligence Aided Architectural Design

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Abstract: Technological advancements have created new dimensions in various fields, including architecture. The widespread use of information technology has particularly transformed architectural designs. In architectural design processes, methods and tools have diversified beyond traditional approaches, incorporating computer-aided programs, computational functions with plugins, and even contemporary artificial intelligence (AI)-supported software and applications tailored to specific needs. It is inevitable that AI-supported designs will increasingly feature in the future of architecture. The purpose of this study is to determine the role of AI applications in architectural design. To this end, a bibliometric analysis was conducted on 137 articles related to artificial intelligence and architectural design from the period 1991-2024, sourced from the Web of Science (WoS) database. The analysis focused on main topics, keywords, authors, sources, highly cited articles, and countries. The selected articles were analyzed using VOSviewer to examine the use of AI applications in architectural design. Quantitative analyses providing an overview of the topic are presented in tables, graphs, and maps. It has been determined that at least 30% of the studies were conducted in the field of architecture. It was found that studies on the subject have rapidly increased since 2020. The continued growth of AI usage across all fields is expected to extend into architectural design as well. Therefore, it is deemed necessary to address AI in architectural design education to align with these advancements. Finally, the paper discusses forward-looking recommendations on how to incorporate AI into architectural design education.

Keywords: Architectural design, Architectural education, Artificial intelligence (AI), Bibliometric analysis.

1. Introduction

Technological advancements have, as in other fields, introduced various perspectives within architecture. Particularly with the increased use of information technologies, architectural design processes have undergone significant transformation. In architectural design processes, which can be summarized as problem-solving through the synthesis of theoretical knowledge, inquiry, research, development, and application, the methods and tools required are continuously evolving in line with contemporary advancements.

Today, the tools and approaches used by architects have become crucial elements affecting the design and process of buildings. Applications ranging from sketches and two-dimensional drawings to physical models, and even to the creation of specialized design tools for specific solutions, are now part of the process. The automation of architects' work began with computational functions added to traditional computer-aided design tools. With advancements in information technology, architects are increasingly inclined to use specialized tools and even AI (Cudzik & Radziszewski, 2018). Recent technological developments are even enabling AI-supported unique designs. It is inevitable that AI-supported designs will become more widespread in the field of architecture in the future. Therefore, examining the relationship between artificial intelligence and architecture today and discussing advancements in this area are crucial for determining the place and potential of AI applications in the future of architecture. In this context, creating new perspectives on how architectural education should be updated is essential for staying current.

In recent years, artificial intelligence (AI) research has been gaining significant momentum. AI-based systems enable the development of design tools specifically tailored for architects to address particular problems. The integration of AI applications into architectural practice is also causing significant shifts in architectural education. Both students and educators may encounter challenges in adapting to these processes during learning and teaching phases. With the advent of digital transformation, the integration of AI applications into innovative educational approaches has become a point of critical discussion. Evaluating AI applications alongside digital learning approaches in architectural design education is crucial for understanding the current state of architectural education and ensuring smooth adaptation to new methodologies. This study aims to assess the place of AI developments in architectural design, providing significant contributions to the future of architectural education.

The aim of this study is to determine the place of AI applications in architectural design by measuring usage models through bibliometric analysis and to contribute to the inquiry of their role in future design education. The results provide an overview, structure, and key reference studies on AI in architecture. Additionally, the main objectives of the research include providing a foundation for researchers interested in the topic, serving as a reference point for future researchers, and offering a general perspective on the field. To achieve this, trends emerging from studies published between 1991 and 2024 in the Web of Science database are analyzed. The results are evaluated to create a discussion environment regarding the place of AI applications in architectural design education.

2. Background

Architectural design can be defined as a process of generating solutions either in response to clearly defined problems or, at times, identifying and addressing ill-defined or ambiguous problems. These solutions can be developed not only through traditional methods but also with the support of computerized digital technologies and AI applications. Today, a wide range of computer-aided design (CAD) software, visualization tools, post-production applications, graphic representation tools, and even AI applications specifically designed for these purposes are utilized by both designers and architecture students.

Architectural design education is a learning process characterized by the mutual interaction between the student and the instructor. One of the primary goals of design education is to uncover and cultivate the creative thinking that resides within students. With advancing technology, AI applications, which are increasingly employed in various fields, are now being used by students to generate visual design alternatives in a rapid and practical manner. This is achieved through the use of chatbots that provide written solutions. In this context, it is essential to consider how AI will be integrated into architectural design education.

In line with this, chapter 2.1 provides a brief background on architectural design and presents a literature review on the use of AI in architectural design. Following this, chapter 2.2 offers a brief background on architectural education and discusses the use of AI in architectural education through a literature review. Within the scope of this study, the design studio, which forms the foundation of architectural design education, is framed as a learning environment where the design/learning process takes place.

2.1. Use of AI in Architectural Design

According to Simon (1996: 111), design can be defined as the process of transforming the current state into the desired state. He argues that anyone who is capable of planning this transformation can engage in design. Simon offers another definition of design as follows:

> "Design…means synthesis. It means conceiving of objects, of processes, of ideas for accomplishing goals, and showing how these objects, processes or ideas can be realized. Design is the complement of analysis for analysis means understanding the properties and implications of an object, process, or idea that has already been conceived."

Simon defines design as follows in his description, which can be considered a modeling approach within artificial intelligence (Visser, 2006: 50):

> "Design is inherently computational-a matter of computing the implications of initial assumptions and combinations of them. An omniscient God has no need to design: The outcome is known before the process starts. To design is to gather information about what follows from what one has proposed or assumed. It is of interest only to creatures of limited information and limited computing power-creatures of bounded rationality like ourselves."

According to him, the act of designing can be described as a synthesis activity and a phenomenon involving various combinations based on computation.

Lawson (2005: 3), summarizing architectural design as a process, emphasizes the necessity for a designer to be trained to understand problems that others might find difficult to define and to produce effective solutions. He highlights that such work requires more than just a 'feeling' for materials, forms, shapes, or colors; it necessitates a wide range of skills (Lawson, 2005: 5-6).

In the design process, which is a mental activity, graphical representation techniques are used to externalize the images created. These include traditional two- or three-dimensional drawings and models that evolve from abstract to concrete representations (Güç & Karadayı, 2007). With the integration of computers and communication technologies into the architectural design process, digital technologies have become valuable tools for visualizing the design process in addition to traditional forms of expression (Yıldırım, Özen Yavuz & İnan, 2010). Today, the increasing use of AI applications has undoubtedly introduced a new dimension to this field.

In architectural design, computing relies on calculation and automation. Design software provides various automatic tools that support the creative process. The most suitable for computer-automated design are those that use visual scripting, allowing users to create their own algorithms through a common programming language or visual scripting techniques. No other system offers designers such a high level of control and the ability to create custom design tools suited to their needs and habits. Automated design systems are widely used in contemporary architecture due to their potential to increase productivity and flexibility, even in complex environments, by developing specialized, topic-specific tools (Cudzik & Radziszewski, 2018).

Among many algorithmic design strategies, evolutionary algorithms, swarm intelligence, and neural networks are shifting the computational architectural toolkit towards AI approaches. The evolutionary algorithm computational model provides optimized configurations based on specified goals by adjusting input parameters. Swarm intelligence relies on the collective behavior of self-organizing systems. Neural networks, on the other hand, are machine learning programs based on training with examples of input parameters and corresponding output values, similar to human decision-making processes.

Various forms of AI approaches are used in architectural design processes, each offering new ways to create architectural forms that lead to different spatial effects. However, the role of the architect in the process remains indispensable, as it is the architect's responsibility to select the most suitable solution from the many design options offered by AI with a critical perspective (Cudzik & Radziszewski, 2018).

2.2. Use of AI in Architectural Education

Architectural design education shares several common fundamental characteristics. Design studios are the core component of this education. Conceptually, a studio is a hands-on learning process where answers are sought through a defined design problem (Lawson, 2005: 7). Globally, design education is largely studio-based, where students learn by engaging with problems rather than merely acquiring and applying theory. Architectural design education requires a delicate balance between guiding students to acquire knowledge and experience while not mechanizing their thought processes to the extent that it stifles the emergence of original ideas (Lawson, 2005: 156-157).

With the rapid development of technology today, architectural designs are increasingly supported by computer-aided applications, including drawings, 3D visualizations, and, more recently, the growing use of AI applications, in addition to traditional methods such as hand drawings, sketches, and models. This situation necessitates an architectural education that incorporates new applications alongside traditional academic-based design education.

The use of AI in education has become a significant research topic with the rapid advancement of computer technologies. Over the past two decades, there has been substantial growth in the application of AI in education, ranging from laboratory environments to various field applications. The use of AI in education has evolved into optional approaches for applications such as computer-aided educational design, speech recognition, language processing, and robot control (Jordan & Mitchell, 2015; Yo, 2020).

How design education should be conducted will likely remain as debatable as design itself (Lawson, 2005: 8). AI applications represent a broad field requiring specific goals, provided by a wide range of tools. Thus, determining which AI tools and applications are suitable for particular tasks and learning processes and selecting the scope of instructional content is challenging. Proposing appropriate strategies for AI education in architectural design is both complex and difficult. Identifying suitable AI applications requires substantial practical experience (Başarır, 2022).

The integration of AI into architectural design education equips students with a range of powerful tools to explore new design methods and optimize existing designs. However, to effectively incorporate AI into design education, appropriate educational models and strategies must be developed to adapt to rapid technological advancements (Zhang, Fort & Giménez Mateu, 2023).

3. Method

In this study, bibliometric analysis has been utilized to uncover distribution patterns and trends in the use of AI in architectural design research. The bibliometric analysis method is employed to reveal the current structure of research trends within a specific field and to identify gaps in the literature (Donthu et al., 2021; Tranfield, Denyer & Smart, 2003). This method involves analyzing the relevant literature through statistical and mathematical approaches (Zou, Yue & Le Vu, 2018). It also aids in obtaining an overview of the subject, identifying knowledge gaps, generating new research ideas, and providing intended contributions to the field (Donthu et al., 2021). Additionally, this method facilitates the identification of emerging research areas and promotes collaboration between institutions and researchers (Fahimnia, Sarkis & Davarzani, 2015).

The recent emergence of scientific databases such as Pubmed, Scopus, and Web of Science has made it easier to obtain large volumes of bibliometric data. Bibliometric software such as Bibliometrix, Gephi, VOSviewer, and Leximancer enables the pragmatic analysis of such data (Donthu et al., 2021). For this study, the Web of Science (WoS) database was used for bibliometric analysis. A search conducted on March 3, 2024, using the keywords "artificial intelligence," "architectural design," and "architecture" resulted in a total of 260 studies. The analysis focused on articles published in scientific journals, which represent a sample of international scientific activity (Velasco et al., 2011; Durán-Sánchez et al., 2018), excluding editorials, news, meeting papers, conference proceedings, books, chapters in books, technical reports, and other types of documents. A total of 137 articles from various disciplines/fields, ranging from the earliest data in 1991 to the most recent in 2024, were analyzed using VOSviewer software. The obtained data was examined through year, co-authorship, country, keyword, and citation analyses (Figure 1).

4. Findings

In the study, a total of 137 articles related to architectural design and AI were identified through a search conducted on the Web of Science. The increase in the number of articles

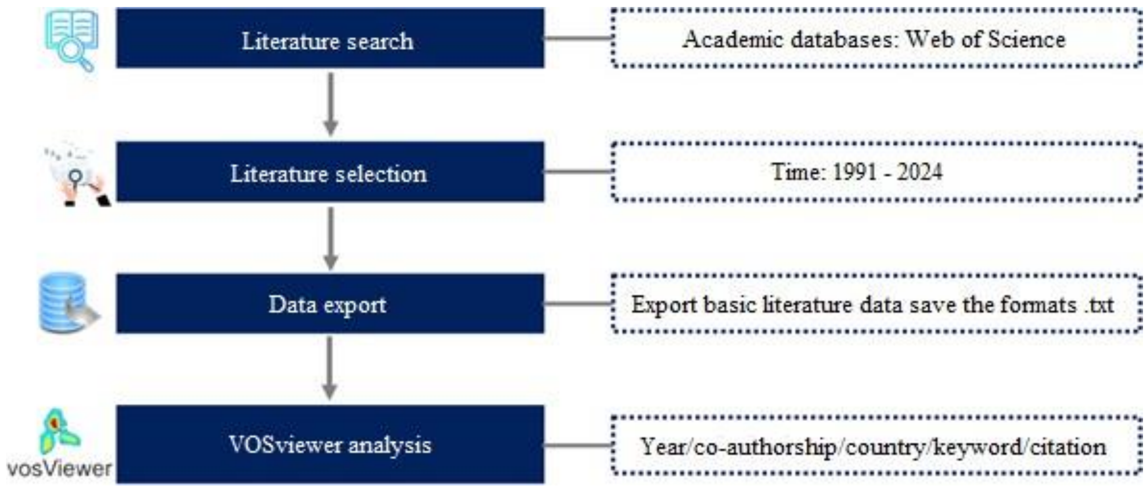

Figure 1: *Methodology used in the research*

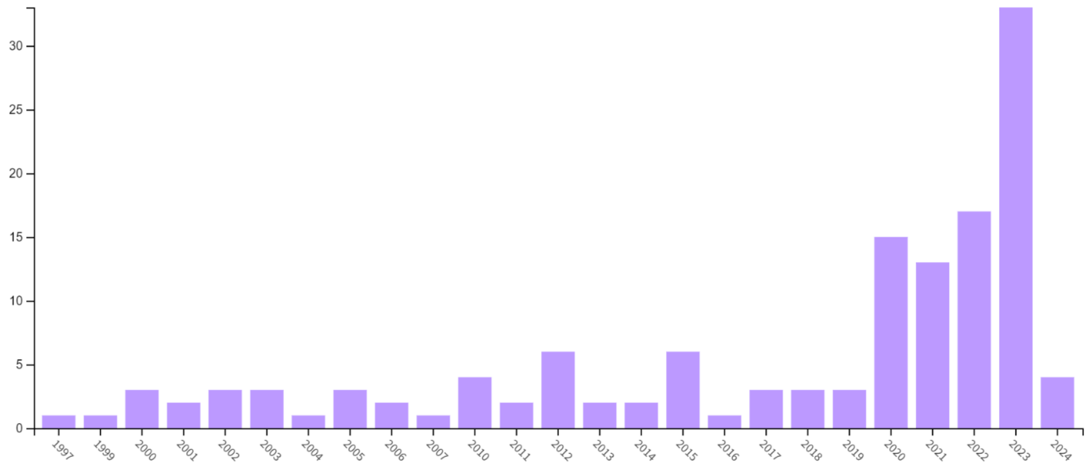

Figure 2: *Yearly growth graph of studies conducted in the fields of AI and architectural design*

over the years is illustrated in Figure 2. In the WoS database, which includes keywords such as artificial intelligence, architectural design, and architecture, there were at most 6 articles per year from 1991 to 2019. However, in 2020, there were 15 articles; in 2021, 13 articles; in 2022, 17 articles; and in 2023, 33 articles. As depicted in the graph, a noticeable surge in the number of publications related to the topic is evident starting from 2020, with a significant spike observed particularly in 2023 (Figure 2). The number of articles published in 2023 constitutes 24% of the total number of publications on the subject.

As shown in Figure 3, in the analysis of co-authorship with the keywords "artificial intelligence," "architectural design," and "architecture," the most connected authors include Jonathan Byrne, Michael Fenton, Erik Hemberg, Martin Hemberg, James McDermott, Ciaran McNally, Michael O'Neill, Elizabeth Shotton, and John Mark Swafford.

The countries with the highest number of publications on the topic are as follows: the United States (31 articles), China (22 articles), the United Kingdom (11 articles), Türkiye (10 articles), Germany (10 articles), Spain (8 articles), Belgium (7 articles), and Italy (6 articles). In the co-authorship analysis with the keywords "artificial intelligence," "architectural design," and "architecture," Spain is identified as the country with the highest level of

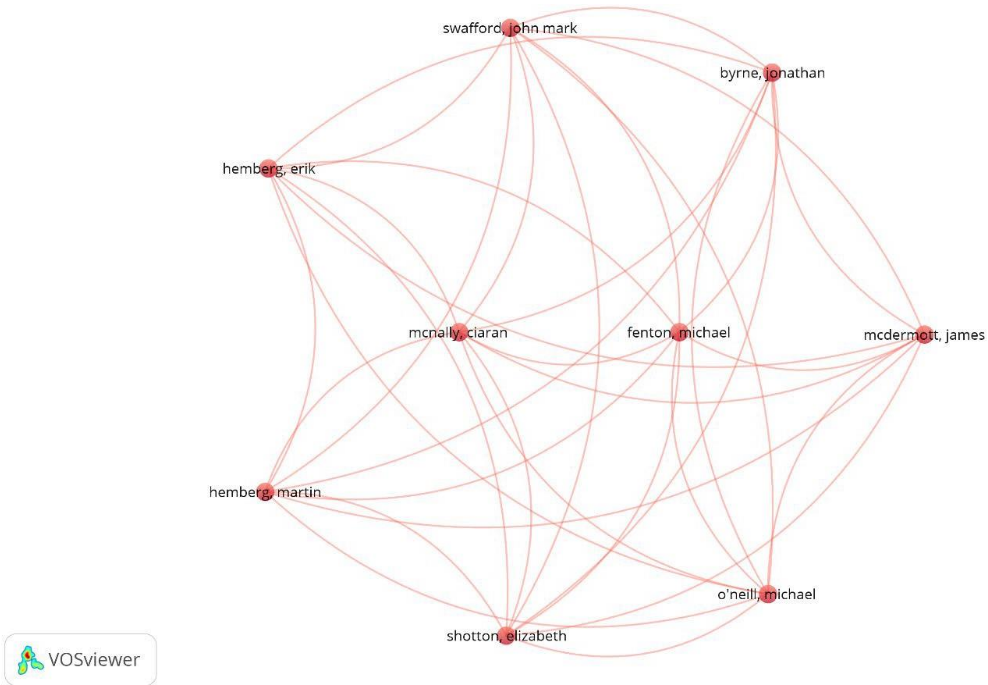

Figure 3: *Co-authorship analysis*

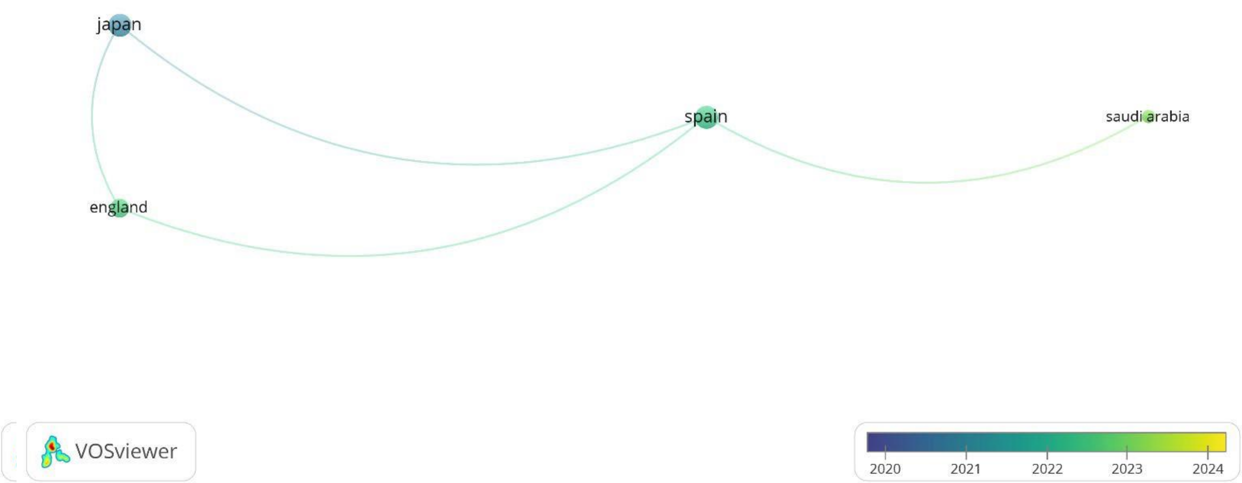

Figure 4: *Country co-authorship analysis*

collaboration (3 articles), followed by the United Kingdom, Japan, China, and the United States (2 articles each) (Figure 4).

Figure 5 illustrates the connections among the total of 265 keywords that appear at least once in the Web of Science search for the keywords "artificial intelligence," "architectural design," and "architecture." The top 10 keywords based on their frequency of occurrence are: "artificial intelligence" appearing 25 times, "architectural design" 13 times, "architecture" 8 times, "generative design" 4 times, "deep learning" 4 times, and "design process," "machine

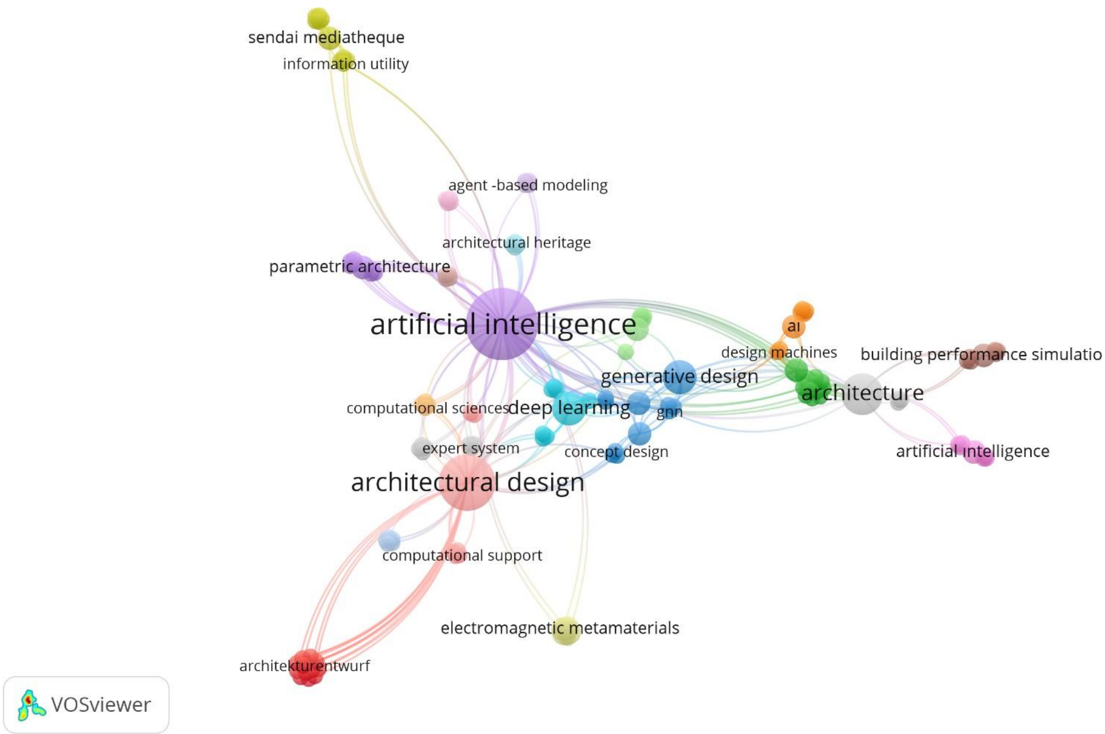

Figure 5: *Keyword analysis*

learning," "parametric architecture," "shape grammar," and "information metamaterials" each appearing 2 times.

Figure 6 illustrates the connections among the total of 58 keywords that appear at least once in the Web of Science search for the keywords "artificial intelligence" and "architectural education". Some of the featured keywords are: “futurism”, “image generation”, “immersive design”, “room configuration”, “space syntax”, “student-centred learning”, “text/image-to-image”, “virtual reality”, “digital drawing”, “digital transformation”, “curriculum learning”, “architectural form generation”, “architectural programming”, “architectural cognition”, “architecture design workflow”.

Table 1 presents the analysis of citation sources from the Web of Science for the keywords "artificial intelligence", "architectural design" and "architecture". The table lists the author names, publication years, titles, citation counts, and Web of Science categories for the top 10 most cited publications. It is observed that the highly cited publications focus on architecture, computer science, artificial intelligence, building technology, and environmental studies.

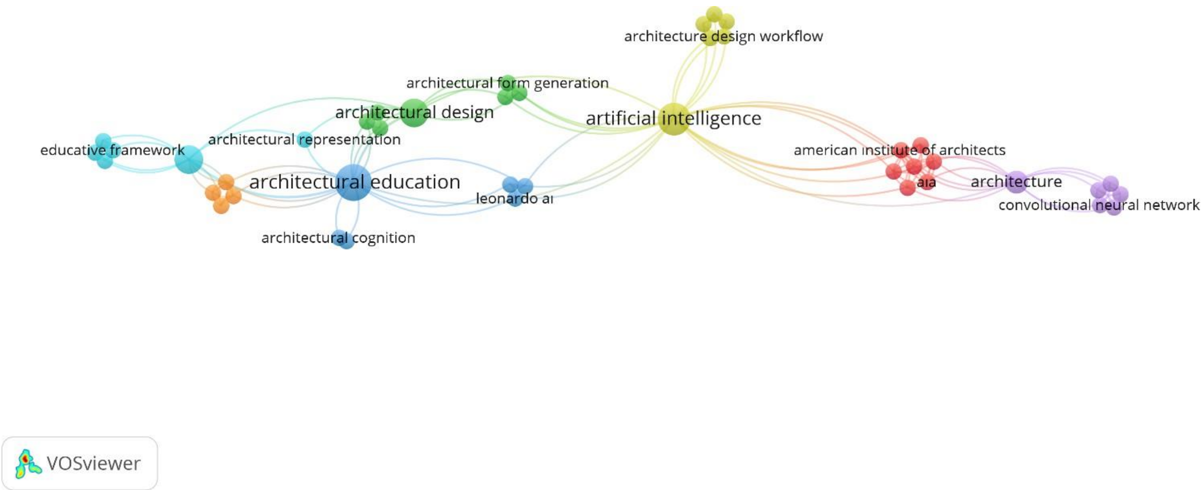

Figure 6: *Keyword analysis*

Table 1: *Information on the top 10 most cited publications*

No	Author	Year	Publication Title	Citation Count	Web of Science Category
1	As, I., Pal, S. & Basu, P.	2018	Artificial intelligence in architecture: Generating conceptual design via deep learning	60	Architecture
2	Do, E.Y.L. & Gross, M.D.	2001	Thinking with diagrams in architectural design	58	Computer Science, Artificial Intelligence

3	Wortmann, T., Costa, A., Nannicini, G. & Schroepfer, T.	2015	Advantages of surrogate models for architectural design optimization	52	Computer Science, Artificial Intelligence, Engineering, Multidisciplinary
4	Escobar, R. & De la Rosa, A.	2003	Architectural design for the survival optimization of panicking fleeing victims	41	Computer Science, Artificial Intelligence, Cybernetics
5	Werner, S. & Long, P.	2003	Cognition meets Le Corbusier - Cognitive principles of architectural design	30	Computer Science, Artificial Intelligence, Psychology, Experimental
6	Su, Z.Z. & Yan, W.	2015	A fast genetic algorithm for solving architectural design optimization problems	17	Computer Science, Artificial Intelligence, Engineering, Multidisciplinary
7	Yi, H. & Kim, Y.	2021	Self-shaping building skin: Comparative environmental performance investigation of shape-memory-alloy (SMA) response and artificial-intelligence (AI) kinetic control	13	Construction & Building Technology, Engineering, Civil
8	Yi, H.	2020	Visualized Co-Simulation of Adaptive Human Behavior and Dynamic Building Performance: An Agent-Based Model (ABM) and Artificial Intelligence (AI) Approach for Smart Architectural Design	12	Green & Sustainable Science & Technology, Environmental Sciences, Environmental Studies
9	McDermott, J., Swafford, J.M., Hemberg, M., Byrne, J., Hemberg, E., Fenton, M., McNally, C., Shotton, E. & O'Neill, M.	2012	String-rewriting grammars for evolutionary architectural design	12	Environmental Studies
10	Wang, L.K., Janssen, P. & Ji, G.H.	2020	SSIEA: a hybrid evolutionary algorithm for supporting conceptual architectural design	10	Computer Science, Artificial Intelligence, Engineering, Multidisciplinary

As illustrated in Figure 7 and Table 1, the most-cited publication is a 2018 study by As et al. on AI in the field of architecture. The key terms of the study include architectural design, conceptual design, deep learning, artificial intelligence, and generative design. The study presents a model that utilizes graphics to create conceptual designs through deep learning. The system developed by As et al. (2018) enables the evaluation and scoring of designs using a variety of deep learning tools, allows the decomposition of designs into fundamental building blocks, and facilitates the recombination of these blocks into new design variations.

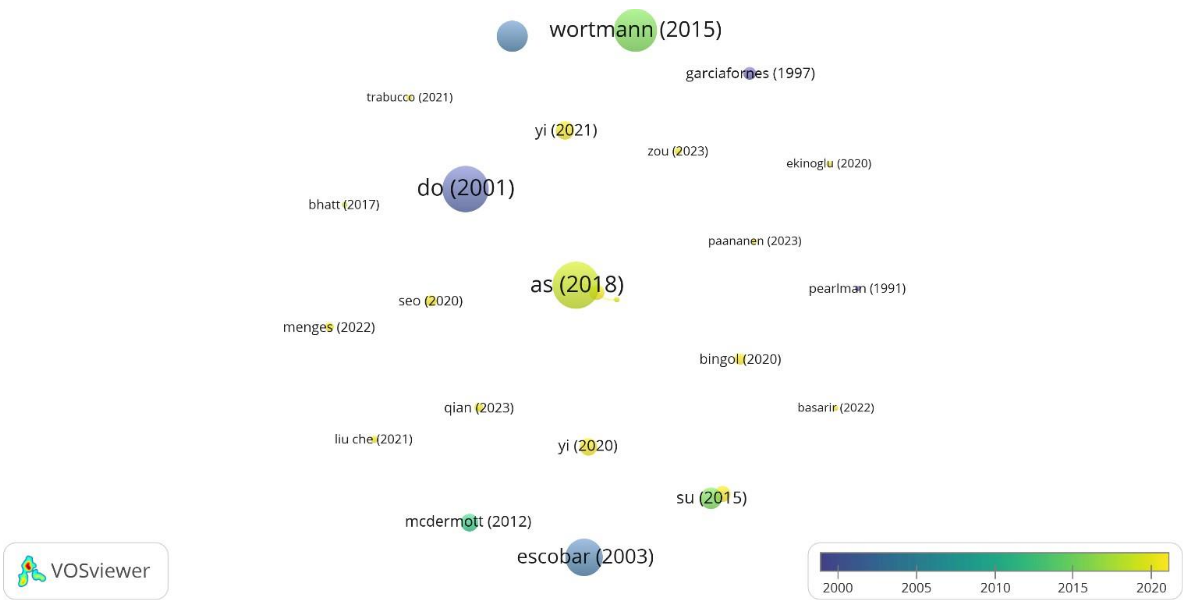

Figure 7: *Source citation analysis*

5. Discussion and Conclusions

Recent years, particularly since 2020, have seen a significant increase in the number of studies related to AI, underscoring the growing importance of this topic within the field of architectural design (Figure 2). Currently, AI research has accelerated to facilitate the development of AI-based systems specifically designed for architects. The Web of Science (WoS) database lists 14 studies published in 2024 related to AI-supported architectural design. The content analysis of these studies is presented in Table 2.

Table 2: *Content analysis of studies related to AI in the field of architecture conducted since the beginning of 2024*

No	Author	Year	Publication Title	Content
1	González, A.F. & Garcia, M.	2024	A Posthuman Architectural Artificial Intelligence Speculum? Text and Images in Future Spaces	To what extent can AI assist in the development of superhuman architectures, and how can we explore the symbiotic relationship between language and artificial intelligence as a means of speculating about the future of space?
2	Bottazzi, R., Hosmer, T. & Claypool, M.	2024	Disruptive Ecologies: Design with Nonhuman Intelligences	Innovative research examining various aspects of design and digital technology (biotechnology, computation and artificial intelligence, digital fabrication, robotics)
3	Sukkar, A.W., Fareed, M.W., Yahia, M.W., Mushtaha, E. & De Giosa, S.L.	2024	Artificial Intelligence Islamic Architecture (AIIA): What Is Islamic Architecture in the Age of Artificial Intelligence?	Investigating the impact factors of AI technologies on the understanding and interpretation of traditional Islamic architectural design processes

4	Ploszaj-Mazurek, M. & Rynska, E.	2024	Artificial Intelligence and Digital Tools for Assisting Low-Carbon Architectural Design: Merging the Use of Machine Learning, Large Language Models, and Building Information Modeling for Life Cycle Assessment Tool Development	A new AI-assisted approach to optimizing the environmental impact of architectural projects
5	Jo, H., Lee, J.K., Lee, Y.C. & Choo, S.	2024	Generative Artificial İntelligence and Building Design: Early Photorealistic Render Visualization of Facades Using Local İdentity-Trained Models	Developing an additional training model to generate alternative architectural design options based on local identity through the application of generative AI in building facade design
6	Tan, L.N. & Luhrs, M.	2024	Using Generative AI Midjourney to Enhance Divergent and Convergent Thinking in an Architect's Creative Design Process	An architectural design methodology utilizing Midjourney, a text-to-image generative AI software
7	Jin, S.T., Tu, H.J., Li, J.F., Fang, Y.W., Qu, Z., Xu, F., Liu, K. & Lin, Y.Q.	2024	Enhancing Architectural Education through Artificial Intelligence: A Case Study of an AI-Assisted Architectural Programming and Design Course	Evaluating the impact of AI technology-assisted instruction on student learning in architectural education
8	Karimi, H., Adibhesami, M.A., Hoseinzadeh, S., Salehi, A., Groppi, D. & Garcia, D.A.	2024	Harnessing Deep Learning and Reinforcement Learning Synergy as a Form of Strategic Energy Optimization in Architectural Design: A Case Study in Famagusta, North Cyprus	Presenting a new framework utilizing AI technologies to enhance energy efficiency in architectural design
9	Zhang, Z.H., Fort, J.M. & Mateu, L.G.	2024	Decoding Emotional Responses to AI-Generated Architectural İmagery	Examining the impact of architectural education on emotional perception and the ability of AI to evoke specific emotional responses through architectural imagery
10	Zhao, L., Song, D.X., Chen, W.Z. & Kang, Q.	2024	Coloring and Fusing Architectural Sketches by Combining a Y-shaped Generative Adversarial Network and a Denoising Diffusion Implicit Model	Developing an AI tool for coloring and integrating architectural sketches
11	Kakooee, R. & Dillenburger, B.	2024	Reimagining Space Layout Design Through Deep Reinforcement Learning	Presenting a new framework that leverages the potential of deep reinforcement learning algorithms to optimize spatial layouts
12	Jang, S., Lee, G., Oh, J., Lee, J. & Koo, B.	2024	Automated Detailing of Exterior Walls Using NADIA: Natural-Language-based Architectural	Performing architectural detailing through natural language-based AI applications

			Detailing Through Interaction with AI	
13	Yan, L.A., Chen, Y.L., Zheng, L. & Zhang, Y.	2024	Application of Computer Vision Technology in Surface Damage Detection and Analysis of Shedthin Tiles in China: a Case Study of the Classical Gardens of Suzhou	Detection and analysis of surface damage on materials using AI tools
14	Jurshari, M.Z., Tazakor, M.Y. & Yeganeh, M.	2024	Optimizing the dimensional ratio and orientation of residential buildings in the humid temperate climate to reduce energy consumption (Case: Rasht Iran)	Calculating energy consumption through artificial intelligence software to optimize building aspect ratios and orientations while minimizing energy usage

Table 2 illustrates that recent studies related to AI in architectural design encompass various methodologies, including: how AI-supported architectural design can be realized, the application of specific AI tools for various purposes, the integration of customized software tailored to design objectives, and the use of AI technologies to minimize environmental impacts and enhance energy efficiency. Additionally, these studies explore how these methodologies can be incorporated into architectural design education.

As evidenced by current research, designing and constructing buildings and cities through superhuman – non-human AI, robotic technology, and smart technologies, and adapting these advancements to design education are key areas of focus. The technological era necessitates the integration of AI applications into architectural design. While the ambiguous nature of design problems complicates the effective application of AI-based tools and services, the integration of AI into architectural design is transforming design education as well.

Teaching architecture in the digital age is a challenging task that requires constant adaptation. The rise of AI has sparked numerous discussions about its potential uses for architects. Due to this revolutionary advancement in technology, students are able to utilize intelligent design tools to generate and evaluate design solutions, analyze data, simulate building performance, and explore innovative ideas. This situation necessitates the continued examination of AI's role in architectural design and, by extension, its implications for architectural design education. While AI holds the potential to revolutionize the field of architecture, it also presents new challenges and considerations for architectural education. Thus, it is crucial to reflect on how AI tools and applications will be incorporated into design education to stay current with developments.

The results of this study provide a general overview and structure of the literature on AI-supported architectural design. Furthermore, examining how the topic is addressed within the field of architecture offers academic and research insights to scholars and researchers, providing a comprehensive perspective on the subject at its current and future state. Additionally, it serves as a foundational reference for future researchers interested in the topic.

To advance research in the field, models developed by researchers such as González, A.F. & Garcia, M. (2024), Bottazzi, R., Hosmer, T. & Claypool, M. (2024), Jin, S.T., Tu, H.J., Li, J.F., Fang, Y.W., Qu, Z., Xu, F., Liu, K. & Lin, Y.Q. (2024), Tan, L.N. & Luhrs, M. (2024), Başarır, L. (2022), and As, I., Pal, S. & Basu, P. (2018) could be applied to architectural education, providing a basis for evaluating challenges and opportunities.

The identification of the increasing use of AI applications in the field of architectural design underscores the significance of technology-based applications in architectural design education and the necessity for their permanent integration into the learning process. In this context, developing course alternatives that incorporate various AI applications into the curriculum is crucial for keeping pace with current advancements. Finally, updating the curriculum as needed is considered essential for adapting the process to architectural education.

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Integrating Text-to-Image AI in Architectural Design Education: Analytical Perspectives from a Studio Experience

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Abstract: This paper examines the integration of artificial intelligence (AI) into architectural design education, with a particular focus on the utilization of text-to-image AI tools in a third-year design studio project at Atılım University. The objective of the project was to examine the potential of AI-supported visual representation tools in conceptualizing future public spaces in Ankara. The study employs a combination of practical experimentation and theoretical analysis to examine the impact of text-to-image AI tools on design thinking and processes, as reflected in student projects generated through these tools.

The research underscores the potential of integrating AI into architectural design education to foster creativity and critical thinking, emphasizing the underlying design principles and methods beyond mere visual outputs. The principal findings demonstrate that AI tools have the capacity to considerably extend the scope of design possibilities, assisting students in transcending the conventional boundaries of design. However, the research underscores the necessity of striking a balance between visual outputs and conceptual depth, ensuring that AI serves as an aid rather than a replacement in the comprehensive design process.

A robust theoretical framework is vital for guiding AI integration and fostering critical understanding and thinking among students. This research contributes to the ongoing discourse on the role of AI in reshaping architectural practice and education, proposing a balanced approach that values both technological proficiency and conceptual depth.

Keywords: Architectural education, Artificial intelligence, Design process, Design studio.

1. Introduction

The instruments and media that facilitate architectural design and representation have had a significant historical impact on architectural practice and thought. Digital tools like computer-aided design (CAD) were initially used to produce drawings more rapidly, but they have since had a considerable impact on the culture of architectural design. The design process has evolved beyond simple geometry through the use of technologies like parametric design and Building Information Modeling (BIM) (As & Basu, 2021, Chaillou, 2022). This has contributed to the development of more intelligent systems capable of providing additional information such as material costs and properties (As & Basu, 2021).

Artificial intelligence (AI) has started to become an important consideration in the field of architecture in recent years. Artificial Intelligence is characterized as a form of programming that imitates the working principle of the brain's neural network system. AI is employed in various fields of architecture, especially concerning text-to-image diffusion models and Generative Adversarial Networks (GANs). These artificial intelligence techniques are essential to the design, representation, and data analysis processes in architecture (Chaillou, 2022)

AI has started to have a significant impact on architectural practice and education. A constantly evolving framework for architectural education ought to give the coming generation of architects a theoretical grounding in addition to emphasizing skill development. The use of AI in architectural design demands a reassessment of design process awareness, techniques, and representation. To emphasize the importance of concepts and ideas in the architectural design process and make sure that visual representations are understood as reflections of these ideas, it is imperative to incorporate AI into the educational setting and promote conversations about it.

The purpose of this research is to examine how AI can be incorporated into architectural design processes and assess how it affects design concepts and principles. According to this study, AI should offer a solid theoretical foundation in addition to helping with skill learning. In particular, text-to-image AI applications, although producing an extensive variety of results, give rise to concerns about reducing design to its visual aspect, prompting the need for further investigation. Analyzing the impact of text-to-image AI techniques on design concepts and principles is essential. The design studio serves as an ideal setting for undertaking such investigations.

In this regard, a project was implemented in the third-year studio of the Atılım University Department of Architecture. The project aimed to explore the contribution of text-to-image AI tools to the design process, discuss the integration of these tools, and understand their contribution to ideas and principles. Titled "Rethinking Public Spaces in the Second Century of the Republic: The Past-Present-Future of Public Spaces in Ankara," this project examined the use of AI as a design environment. By investigating the past and assessing the present conditions of public spaces in Ankara while envisioning their future, text-to-image AI applications were employed. The project aimed to recognize the significance of these spaces in stimulating community, democracy, and identity, and to use these skills to develop creative architectural spaces for the future.

This project included using text-to-image AI tools to transform texts and scenarios into spatial representations and analyzing the impact of this experience on design thinking and processes. The possibilities of these AI applications in architectural design education are discussed in this context, together with the difficulties and solutions posed by the quick advancements in technology that have a significant impact on architectural design.

This study employs both qualitative and quantitative research methods to explore the incorporation of AI tools into architectural design education. The literature review on AI in architectural design and education establishes the theoretical framework. Selected projects created by students in an AI environment are introduced and analyzed with an emphasis on the effectiveness of the utilization of AI tools to convey their design ideas and principles. The findings are discussed across several key topics, including the relationship between architecture, expression, and space; the necessity of a conceptual foundation; the development of AI skills; the importance of textualization; and the ongoing development of AI discourse.

2. Theoretical Framework

2.1. Artificial Intelligence and Architecture

Artificial intelligence (AI) is defined by Russell and Norvig (2020) as a form of programming that provides the ability to mimic human reasoning and problem-solving. According to this definition, AI includes the ability of a computer system to analyze data, learn from it, and make similar decisions as human beings.

As humans cannot individually create, calculate, and assemble billions of data, computers can perform many tasks extremely quickly. This ability leads to a major change in how problems are solved, as computers can do things much faster and differently than humans. The term “Big Data” describes this difference, referring to data that is too large for humans to handle, but manageable for computers (Carpo, 2023).

According to Carpo (2023), intelligence as a design tool is limited to tasks involving measurable factors although architectural design is not easily converted into numbers. It can provide and process analytical data which helps the decision-making process. Architectural drawings have been digitized for a long time but no standard metric exists to evaluate architectural design values (Carpo, 2023). AI applications range from predictive analysis to optimization of building performance and user experience to form-finding, space planning, and fabrication in construction phases (As, 2021). Carpo (2023) claims that only certain parts of a design can be optimized using AI tools, as long as they produce measurable results and even then, most quantifiable problems will have multiple parameters, requiring someone to prioritize and make choices.

Similarly, İmdat As (2018) claims that architectural design relies on abductive reasoning, so these tools aren't very helpful in the early stages of the design process. Architecture allows for multiple solutions to the same spatial problem, meaning there isn't just one correct answer but current computer-aided design (CAD) tools are based on inductive and deductive reasoning, which work well for engineering, not for design (As, 2018). They are more useful in the later phases when most design decisions have already been made. It is important to produce alternative solutions for decision-making therefore, students are more encouraged by their instructors to use sketch rather than CAD programs which allows them to quickly come up with multiple design ideas without getting overwhelmed by CAD details (As, 2018). However, As (2018) claims that, the lack of computational tools for the early design stages is a gap that machine learning might help fill.

With the recent development, GANs and diffusion models can be used as generative models in non-measurable architecture-related fields. Like diffusion models, GAN technology is used as an image processing tool trained to identify similarities between a collection of images categorized under the same label or concept using a discriminator and a generator (Figure 1) (Chaillou, 2022).

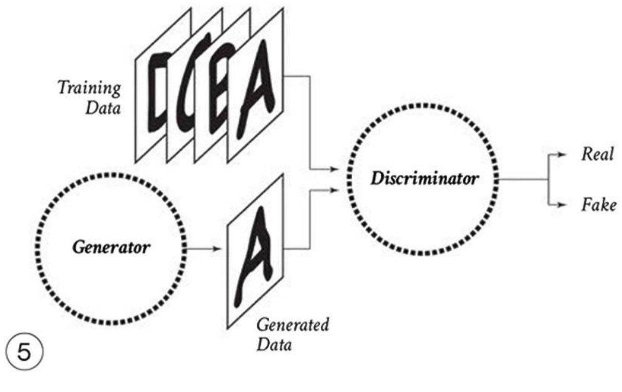

Figure 1*: GAN Technology explained. Source: Chaillou, 2022*

For example, a dataset containing millions of classified images can be trained to recognize patterns and commonalities within this group of images (Carpo, 2023). Both GANs and diffusion models produce data similar to the data on which they are trained; however, diffusion models-including models that generate images from text-have proven more successful than GANs in this regard, and their use has recently increased in many fields, including architecture (Dhariwal & Nichol, 2021).

AI has become increasingly important in architectural design due to its ability to analyze and generate patterns and symbols. Image generators can translate abstract architectural concepts into tangible forms, revolutionizing the creative process and redefining the traditional limits of human design. The advent of artificial intelligence (AI) has introduced new possibilities for architectural design, particularly through the use of AI-generated images. It makes a significant contribution to the design process by providing a wide range of outcomes, providing a set of exemplar outcomes, and filtering them to select the most appropriate one (del Campo & Maninger, 2022). However, Del Campo and Maninger (2022) argue that if the notion of a singular design is replaced by a set of potential exemplars, these should be referred to as "outcomes", and if the process of generating these exemplar options is based on such a set of "outcomes" rather than the generation of a singular design, this process should be referred to as "searching" rather than "designing.

According to Del Campo and Maninger (2022), when all possible solutions already exist, it is only a matter of doing the right "searching". In other words, it is not about the designer "inventing" some new proposals by using his or her own "genius", but about choosing the best solution among the possible options available. As a result, it can be said that artificial intelligence does not need to catch up with human intelligence, and is already much more efficient than human intelligence in exploring the set of possible "outcomes" in any "design" search process. In this context, the concepts of "consciousness" and "search" in the design process are directly related, and this relationship can provide an important awareness of the danger of architectural practice becoming a visual game, and the danger of creating an architectural language through "isms" or styles. Design problems involve a multifaceted process. The more deeply one examines the ideas, problems, and values behind architectural design, the more "conscious" the design produced and the more successful it is considered to be when it is successfully synthesized and translated into an architectural language.

2.2. Integrating Artificial Intelligence into Architecture Education and the Importance of Discussing it in Education

The characterization of paper-based design thinking as the basis of design education is generally accepted (Tepavčević, 2017 as cited in Schön & Wiggins, 1988; Oxman, 2008), and the introduction of CAD (computer-aided design) did not revolutionize the process of design thinking. While CAD is seen as a tool that mimics paper-based design, DAD (digital-architectural design) replaces the paper-based media approach with new concepts such as digital design models (Tepavčević, 2017 as cited in Kalay 2004), new design thinking (Tepavčević, 2017 as cited in Oxman, 2017), and new concepts of space (Tepavčević, 2014). For this reason, it is important to integrate artificial intelligence into education and even discuss a theory of architectural education and design pedagogy that incorporates the theoretical, professional, and technological changes that digitally mediated architecture is beginning to implement.

In the design and decision-making phase in architectural education, it is a healthy process to evaluate possibilities and search among available alternatives up to the threshold of acceptability. The role of AI can be seen as expanding these possibilities and as a source of inspiration.

Accepting that artificial intelligence is a means of generating possibilities, it would not be wrong to say that its inclusion in the educational process is necessary both to explore the potentials of artificial intelligence and to discuss the consciousness in these possibilities, and to take the discussions on the relationship between architecture and artificial intelligence beyond the dimension of mere visuality. In this way, instead of looking at the visuals produced by artificial intelligence in a result-oriented way, it is possible to emphasize the ideas behind the visuals, the process and method of their creation, and to discuss.

Neil Leach (2022) explores how AI image generation can serve as a tool for engaging students in critical inquiry and challenging conventional design norms (Leach, 2022). He argues that AI-generated images can inspire creativity by presenting unexpected design solutions and encouraging students to think beyond traditional boundaries.

Similarly, Kudless (2024) claims that if generative AI images are thought of as artistic sketches, then sketches are often used in the ideation phase to help generate concepts valuable to artists and designers because they are fast, iterative, and cost-effective, despite their lack of precision. Generative AI images capture the essence and atmosphere of an idea, but instead of being seen as finished renderings, they can be seen as possibilities and examples that can help expand the designer's repertoire. Kudless (2024) adds "As we navigate the intersection of AI and creativity, it is crucial to strike a balance between coherence and creative nonsense to harness the potential of AI as a tool for exploration, dreaming and the creation of new architecture" by drawing attention to the danger of these rapid image-making tools, namely the irrelevance or inexpressiveness of the images produced.

The expression of architecture with fancy visuals is a critical issue that causes it to be reduced to an image instead of complex design ideas and it is in danger of being undervalued with this reductionist approach. The widespread use of AI-generated images may lead to an overemphasis on images at the expense of functionality and contextual relevance. Therefore, it is essential to critically evaluate the role of these tools and ensure that they complement rather than overshadow the comprehensive design process.

A vast number of studies are interested in the effect of text–to–image AI tools on transforming architectural education(Ceylan, 2021). These studies, based on first-year basic design education, directly address key topics such as the impact of artificial intelligence on visualization with storytelling (Sadek & Mohamed, 2023) and the effect of AI on representation forms like sketches and orthographic drawings (Yıldırım, 2022). Tong et al. (2023) have also definitively shown the effect of using artificial intelligence on learning outcomes (Başarır, 2022). Furthermore, research has also examined the impact of AI on creativity in form and façade. (Sadek & Mohamed, 2023, Kavakoğlu et al., 2022). Yıldırım (2022) in his research mentions the use of text-to-image AI image-generation tools as a part of the design process comparing it with sketching as the conventional method of conveying ideas focusing on the textual data from novels. Cudzik and colleagues (2024) encouraged students to use artificial intelligence tools as part of a green campus design project, especially as a source of inspiration, and the new images generated by artificial intelligence were intended to enrich students' understanding and imagination of campus transformation aspects and practices in the same way as visual materials consisting of existing architectural examples. Cudzik et. al. (2024) claims that the images generated allowed new ways of thinking about possible solutions, sparking students' imaginations and stimulating their creativity.

In another study by Yazıcıoğlu and his colleagues (2024), first-year architecture students were given a project topic with the theme of "underground" and were asked to create scenarios about which universe's underground they would design and to sketch and write them down in detail. This study focuses on how and with which task artificial intelligence programs that produce visuals from text can be positioned within the rational and action-oriented way of thinking in the architectural design process. During the workshop, no artificial intelligence program was employed by the student groups in the elaboration of their underground scenarios. In the final stage, descriptive short texts produced for each underground model were written as input to the Dall-e2 program, and visual outputs were obtained. In this study, unlike other studies, artificial intelligence was used only to evaluate the texts produced in the context of accuracy.

While these studies utilize the potential of artificial intelligence, they do not address the issue of architecture being limited to mere visual appeal, neglecting its conceptual, contextual, and functional aspects. In this context, the research conducted in the third-year studio at Atılım University Faculty of Architecture offers a distinctive approach to the subject.

3. Scope and Process of the Project

At the beginning of the Fall 2023-2024 semester, a conceptual project was initiated in the third-year studio of the Atılım University Department of Architecture. The project sought to explore ways of incorporating AI within the design studio process, rather than addressing it as an isolated subject. The objective of the project was to uncover the potential and possibilities of AI as a creative design environment and understand its contribution to architectural design. The project highlighted design concepts, principles, and processes to expand beyond conversations about visual features. The subject matter was theoretically and intellectually challenging, requiring students to do extensive study, have thoughtful discussions, and apply critical thinking skills before coming up with design proposals. The project was entitled "Rethinking Public Spaces in the Second Century of the Republic: The Past, Present, and Future of Public Spaces in Ankara."[1] This two-week conceptual project encouraged students to focus on the transformation of public spaces in Ankara as Turkiye approached its second-century of the Republic.

3.1. Project Process

The project developed along two main axes: an exploration of design content and the application of text-to-image AI tools, which initially proceeded separately but later integrated. Studies related to the design content

***Table 1**: Architectural Design Studio Information*

Architectural Design Studio Information	
Institution	Atılım University
Department	Department of Architecture
Academic term	2023-24 Fall semester
Project Title	Rethinking Public Spaces in the Second Century of the Republic: The Past, Present, and Future of Public Spaces in Ankara
Student Level	3rd year Undergraduate Students
Number of students	44
Project Duration	2 weeks

[1] The studio instructors who participated in the project together with the author Sinem Çınar and Melek Demiröz: Elif Yurdaçalış, Yeşim Hatırlı, Günay Erdem, Kumru Alpaydın, Hakan Evkaya.

aimed to understand the design problem and establish a conceptual foundation, necessitating thorough analysis and research processes. Parallel to this, the other focus was on developing AI usage skills. These initially separate processes converged during the development of design proposals.

The first axis, exploration of design content, involved research, analysis, and discussions to understand the design problem, typical of a classical studio project. New challenges and opportunities for redesigning Ankara's public spaces in the 21st century were considered. The rapid urbanization, growing population, and changing demographics in Ankara have created a necessity for a reconsideration of the city's public spaces. The significance and function of public spaces, transformations in their character, and the conceptualization of public life in the Republic's second century were among the pivotal issues addressed. Creative approaches to inclusive, sustainable, and actively used public spaces were highlighted.

The second axis dealt with the improvement of AI abilities. Students familiarized themselves with AI applications that generate visuals from text, comprehended their operation, and learned fundamental skills through an introductory seminar and workshop.[2] The objective was to understand the limitations, controllability, and potential of AI tools rather than getting involved in the complicated and intensive tasks associated with running algorithms, modifying codes, installing new libraries, or searching for appropriate datasets. Students were encouraged to concentrate on developing textual representation skills of architectural and spatial concepts in order to gain control and approach the best-desired solutions during this two-week project.

Following their analysis of the design problem and theoretical and technical learning of text-to-image AI tools, students began experimenting in an AI setting with their design concepts. With this, the process of creating design concepts for Ankara's public areas was initiated. They explored the potential of AI tools to synthesize design ideas and inspire creativity. This phase involved working with textual representations of design ideas, visualizing new concepts, and refining the design process through discussions on spatial features, key terms, and core principles (Figure 2).

3.2. Student Projects

Four projects were selected for their successful use and understanding of AI as a tool, and they are evaluated in this section.

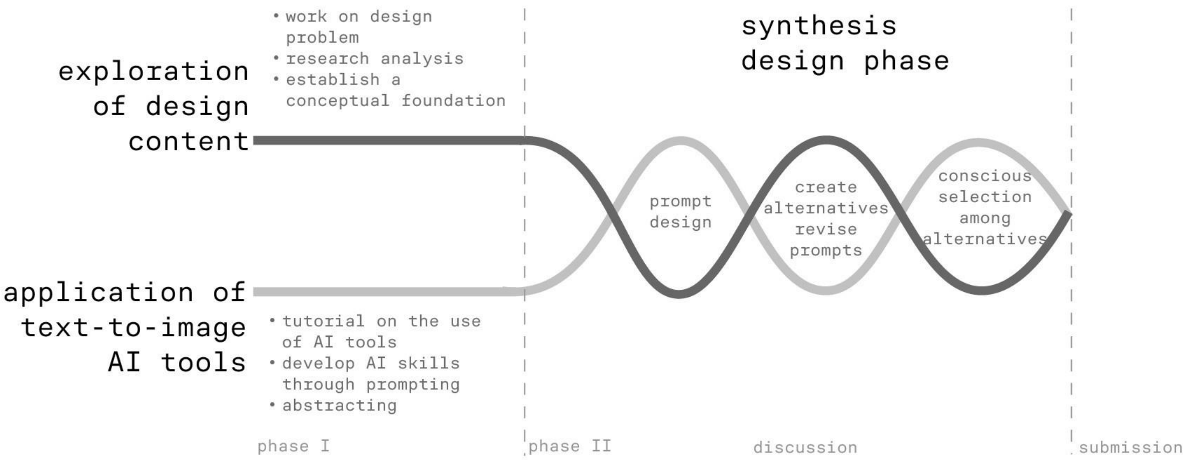

Figure 2: *Project Process. Source: Author*

[2] Melek Demiröz, research assistant at Atılım University GSTMF Department of Architecture, conducted an online workshop titled "Artificial Intelligence Applications in Architecture".

Square spaces, intersecting spaces, group activities, relaxation spaces, interconnected spaces

Wooden structures of different sizes following a straight axis, open spaces, urban fabric, public space formed between its intersection, green texture, sustainability, city square, walking, climbing

Thick wooden structures of different sizes located on a linear axis, transitional spaces and main spaces formed on the structures

Figure 3: *Sude Er, Project images and texts produced at Midjourney*

The first project (Figure 3) aims to create a symbiotic relationship between nature and the built environment. It emphasizes integrating nature with urban life and promotes an active lifestyle through movement and social interaction. The design features a linear axis connecting two prominent urban centers and it envisions public spaces as interconnected platforms enabling three-dimensional spatial relationships across various levels. The wooden frame structures supporting the platforms are adaptable. The platforms of flexible dimensions prioritize human scale, and they serve as transitional spaces for walking, climbing, and cycling, and as spaces for community activities. The spaces between platforms receive sunlight and allow for the growth of trees and plants, enhancing the ecological wellness of the urban environment.

The second project (Figure 4) exemplifies how urban design can adapt to and mitigate environmental challenges, offering sustainable and interactive solutions for future urban living. It envisions a future scenario that addresses the challenges of a growing global population, excessive urbanization, and the resulting reduction of natural resources. It proposes elevated public spaces in the sky, where clean air is provided within spheres, allowing people to breathe without masks. These spheres create ideal living conditions and incorporate advanced technologies such as holograms and digital libraries. Interactive spaces facilitate communal activities and communication,

Gym in a glass sphere in the sky, inside space, sport, swimming, relaxation, futuristic

Futuristic architecture, digital library, people walking around, people sitting, reading books, futuristic architecture

Various plants in a glass sphere in the sky, People walking around, reading books, glass capsules, exhibition, people

Figure 4*: Yeşim Soysal, Project images, and texts produced at Midjourney*

encouraging a sense of community amidst environmental deterioration.

The third project (Figure 5) envisions a more sustainable environment through the integration of green spaces within a multi-layered urban design. The design involves replicating and layering the ground plane in three dimensions. The upper layer features a public green square that connects across a vehicular boulevard to a park on the opposite side. Below the upper layer are enclosed commercial and dining spaces that support public life. When the upper layer intersects with the lower layers, it creates amphitheater-like spaces. The configuration of the layers allows for the creation of semi-enclosed and enclosed areas that facilitate pedestrian and bicycle circulation, thereby enabling a range of activities and social gatherings. Structural openings and voids are incorporated to ensure that the lower layers receive natural light, enhancing the overall spatial experience and sustainability of the design.

The fourth project (Figure 6) aims to revitalize the Republican axis, which was historically planned but compromised due to vehicular traffic. It pedestrianizes Atatürk Boulevard and links significant urban landmarks. The design envisions a linear passage and activity area along the boulevard, characterized by

Figure 5: *Zeynep Sude Arslan, Project images and texts produced at Midjourney*

Figure 6: *Tuğçe Serinken, Project images, and texts produced at Midjourney*

transparent glass surfaces that lightly and gently intervene in the urban fabric. Along this axis, resting areas are incorporated, and historical exhibitions are projected onto the glass surfaces, creating an effort to revive historical consciousness and engagement.

4. Discussion & Conclusion

The project made a substantial contribution to the integration of AI tools and techniques into architecture as well as creativity in the design process. Despite initial challenges in controlling AI-generated visuals of conceptually designed spaces, students gradually developed skills in using language accurately, creating abstractions and concepts, and expressing and conveying these through prompts. Upon the conclusion of this experience, a discussion of the subjects that provoked reflection can be conducted under the following headings.

Relationship Between Architectural Concepts, Spatial Qualities, and Their Representations

Throughout the project, the relationship between the spatial qualities and architectural concepts and their representations was investigated. The features of different artificial intelligence tools were examined for each phase of the architectural design process—concept and idea development, representation, and realization—and the distinctions between them were examined. Throughout the process, students were asked to avoid concepts aimed solely at creating visuals, such as -isms, historical architectural styles, and formal approaches. However, they were not prevented from experimenting with these concepts in keywords during the program discovery process. As a result of the studies conducted, it can be said that artificial intelligence can assist in uncovering architectural knowledge, based on the necessity for the text used in visual production to contain architectural information.

Need for a Conceptual Backbone

The project's outcomes showed that the more focused the design problem and thoroughly examined the ideas, the more satisfying the results. The project process demonstrated that the more the design problem was focused upon and the concepts were extensively scrutinized, the more satisfactory the outcome was. During the design process, generic concepts frequently produced highly standard and uncontrolled consequences, which led to dissatisfying visuals. Clarifying design concepts and principles, as well as the structural system and material selections, was therefore crucial.

Development of AI Skills

The development of AI skills is a gradual and crucial process. Students need ample time to explore both the controlled and uncontrolled aspects of AI. During this journey, students familiarized themselves with AI applications that generate visuals from text, comprehended their operation, and acquired fundamental skills. The objective was to understand the limitations, controllability, and potential of AI tools. Throughout this two-week project, students were encouraged to focus on developing prompting skills for architectural and spatial concepts to achieve the best possible outcomes. Initially, some projects began with very general concepts, but it was later recommended that these concepts be detailed and selected from spatial concepts, architectural design elements, and strategies, rather than architectural styles or periods. General concepts did not enhance the quality of the student's results, whereas more detailed and expressive spatial and architectural concepts yielded more satisfactory outcomes.

Development of Prompting Skills

In the design process, the quality of results obtained from AI-generated visuals directly depended on the detail and architectural knowledge embedded in the text. Students developed their skills in using language precisely, creating abstractions and concepts, and expressing and conveying these visually. They recognized the importance of detailed textual descriptions in achieving high-quality outcomes. Through this experience, students learned that the more nuanced and informed their prompts were, the more sophisticated and accurate the resulting AI-generated visuals became.

Evolving Nature of AI Discussions
Given the rapid development of AI, it must be acknowledged that discussions on this topic are constantly subject to obsolescence. The fact that this project was conducted at the beginning of the 2023-2024 Fall semester indicates that the use of AI reflects the state of a specific period. Consequently, these discussions are destined to become outdated even as they are being conducted. However, the emphasis on ideas and principles –rather than visually-focused designs– in architecture transcends the passage of time and technological changes. This enduring focus ensures that while the tools and methods may evolve, the core values and objectives in architectural design remain unchanging.

Project outcomes suggest that AI can contribute to innovative and contextually relevant public space designs, enriching the educational experience and preparing future architects for contemporary design challenges. The project demonstrates that AI technologies encourage creativity by producing a variety of design solutions, which motivates students to think creatively and beyond the box. Nonetheless, it is crucial to achieve a balance between conceptual depth and visual representation to make sure AI supports rather than dominates the design process. To support students' critical understanding of AI-generated outputs, the project emphasizes the necessity of a strong theoretical foundation for navigating AI integration in architectural design education.

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First-Year Architectural Design Studio in Action: Insights from the 'Timberscapes' Design-Build Experience

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Abstract: The "Design-Build" approach in design studios emphasizes hands-on learning and 1:1 scale production in dynamic environments that encourage teamwork, material understanding, bodily awareness, and collaborative decision-making. This study presents a design-build experience titled "Timberscapes" for the final project in the "Design Studies" studio during the Spring semester of the 2021-22 academic year at Bahçeşehir University, Architecture Department. The project explored collaborative design interventions in the campus's limited open spaces. Over five weeks, students identified campus needs through personal experiences and developed spatial proposals in teams. Three projects were selected involving student participation for different campus locations. In the second phase, due to the unavailability of conditions for their implementation, the projects were further developed with new divisions of labor and expert consultations.

The studio problem emphasized dialogue and negotiation in team-based processes, structured in two stages with changing teams and responsibilities for students. This paper presents the experimental studio process and student outputs, and investigates its contributions for the students. The method involves a literature review of past experiences with design-build method, the pedagogy of teamwork in the design studio, potentials of timber as a sustainable material to be flexibly used in architectural education and presents the current experience as a staged case study. The paper discusses the case study's gains in creating a dynamic negotiation environment in the first-year architectural design studio, and highlights the practical limitations and future implications of the applied process.

Keywords: First-year design studio, Design-build, Timber, Teamwork, Negotiation

Introduction

Design studios, flexible environments facilitating the integrated development of design knowledge and skills, continue to hold a central role in architectural education across Türkiye and the world, employing diverse pedagogical methods and processes. Today, new searches and discussions on the quality of knowledge, the interconnectedness between knowledge and skills, and the methods of their transfer constitute a broad content in design education (Kararmaz & Ciravoğlu, 2017).

Within this plurality, a common approach called "Design-Build" aims at learning by doing and 1:1 scale production in studio education. Designed with the foresight that the final product will be built, these studios are dynamic learning environments that include themes such as materials, construction techniques, details, bodily awareness and experience, teamwork, flexible process design, and communication with users (Kararmaz & Ciravoğlu, 2017). To these can be added, "feeling the power of co-production, discovering limits, learning collective decision-making processes, being the triggers of observing and understanding each other and making" (URL 1). Some key examples from national and international contexts in this field include the summer internships of METU Faculty of Architecture students (Kolektif, 2022; Önür et al., 2006; Turgay, 2005), and the practices of the Rural Studio established and maintained by its founder Samuel Mockbee and his students at Auburn University since 1993, especially as social responsibility projects in non-urban contexts (URL 2). A recent example from Türkiye in this regard is MEF Faculty of Art, Design and Architecture's Design and Build! Studio. Since 2015, the academic staff and students of the university have been designing and building timber structures with various functions in rural and urban contexts in partnership with local governments, non-governmental organizations, and industry in Türkiye and abroad in the summer (Figure 1).

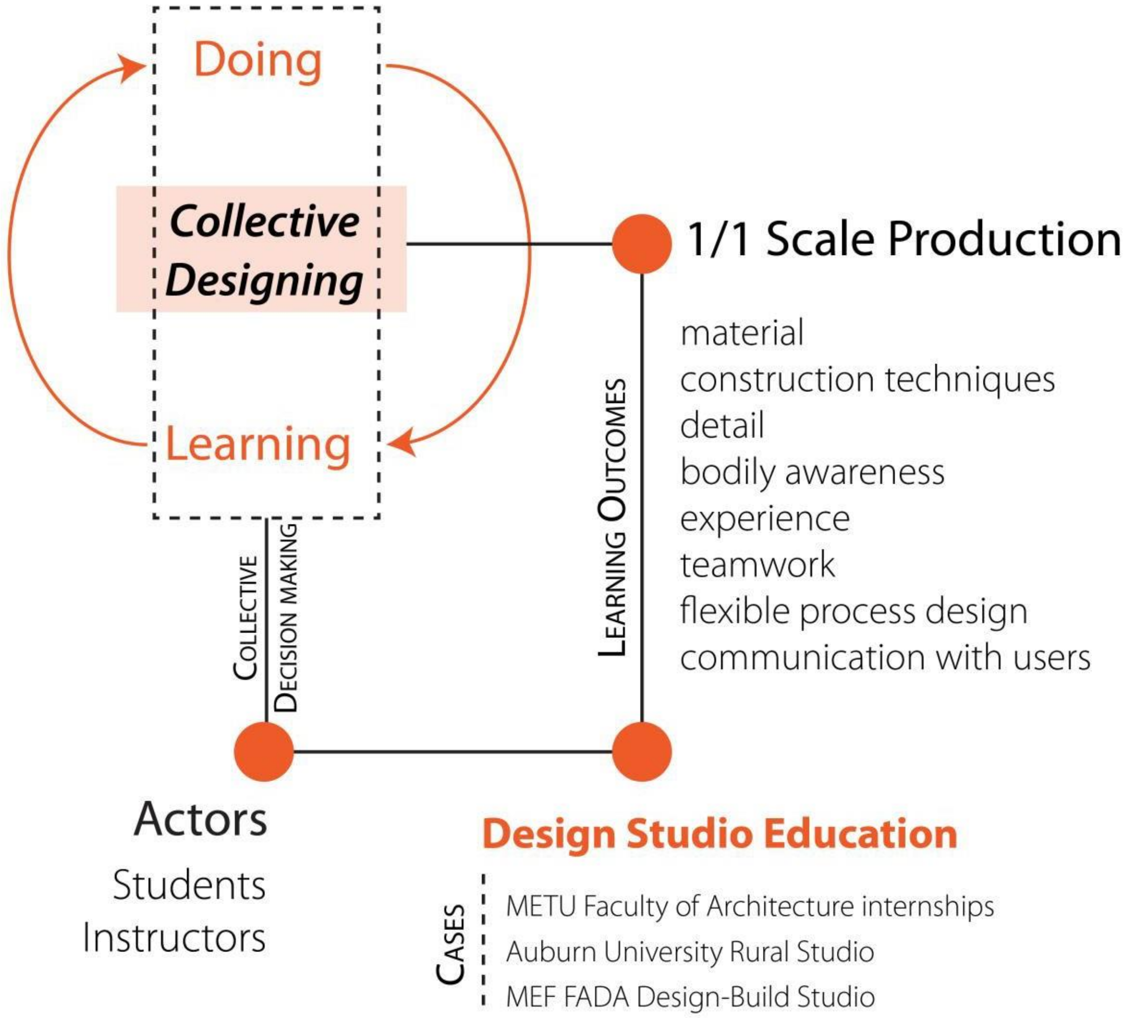

Figure 1: *Design-Build approach as a dynamic learning environment.*

This paper presents a comparable experience designed in response to the post-COVID context of the 2021-22 academic year, right after the extended lockdowns, and implemented during the spring semester of the first-year design studio at Istanbul-based Bahçeşehir University's (BAU) Architecture Department. The first-year design studio serves as an introduction to the broad scope of architectural design and it has a special position among the others due to its high potential to generate innovative methods that are interdisciplinary and experimental. In the presented study, first-year students who had experienced their first-semester studio education online and away from physical interaction during the final stages of the pandemic were introduced a design problem intended to encourage them to engage with their peers and the physical campus environment. This problem prompted them to first consider distancing and then transforming the educational space they had just been part of, stretching its limitations and expanding their experiences through collaborative, team-based projects.

A key point to underline is that the presented studio experience was structured without a predefined focus on future pedagogical evaluation, and thus this paper reflects on the process through experiential insights, student work, and observations rather than relying on pre-planned surveys. The project specifically aimed at initiating a design-build task to get the first-year students in action with teamwork playing a central role, recognizing that their first-semester experience had been online. The three primary objectives of the project were: (1) to initiate a design-build task; (2) to emphasize the importance of teamwork; and (3) to raise awareness of timber as a sustainable material at an early stage of architectural education.

More specifically, the Timberscapes project challenged students to design and construct compact timber structures with flexible programs to be developed for the use of students in the campus's open areas. The process unfolded in two phases: in the first, small teams developed designs for one of three sites over five weeks, culminating in a jury evaluation. In the second phase, larger teams refined the selected projects over the remaining three weeks. The selection process involved student participation, and the projects were planned to be constructed at three different points on the campus as the final part of the studio process. Working with different responsibilities and roles throughout this process, first in small teams and then in larger ones, negotiating within and between teams and of course, with the conditions of feasibility itself, was again at the heart of this problem (Figure 2).

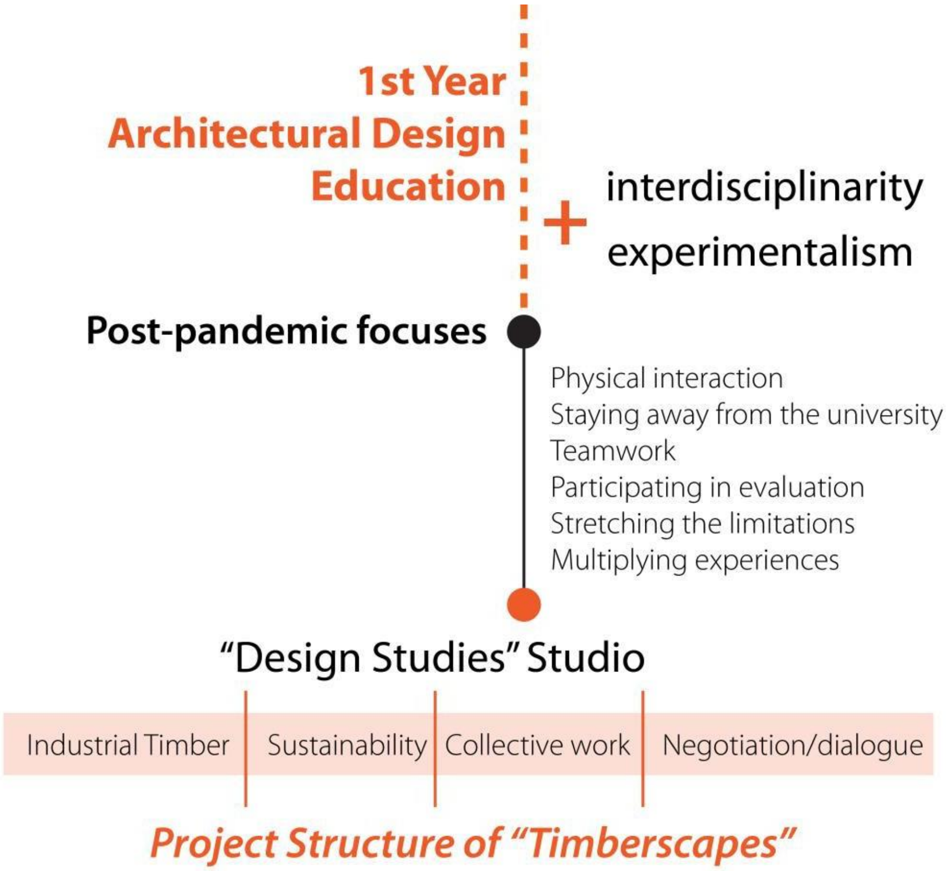

Figure 2: *The focus and structure of the Timberscapes project.*

As with the previously mentioned design-build examples, teamwork was central to the Timberscapes project as a pedagogical model. In architectural education, team-based learning is critical for developing the skills and attitudes necessary for professional practice, as architecture is inherently collaborative. Teamwork skills are considered a vital graduate competency in the accreditation standards for architecture programs in the USA, UK, and Australia (Tucker & Abbasi, 2015). Similarly, the "teamwork and collaboration" competency is included in Türkiye's national architectural education accreditation framework listed under Professional Environment by Türkiye's Association for Accreditation of Architectural Education (MIAK, Mimarlık Eğitimi Akreditasyon Derneği) (URL-3). The potential benefits of teamwork in design education, include the growth of interpersonal and critical thinking skills, fostering active learning, developing abilities to tackle larger tasks collaboratively, enhancing peer learning and capacity for lifelong learning (Tucker & Abbasi, 2015). While conflicts may arise within teams due to differing perspectives, gaining the ability to resolve these conflicts through effective communication is a critical skill in design education (Yair & Press, 2000). Several recent studies highlight the nuanced challenges of teamwork, especially concerning students' diverse and complex perceptions of collaborative processes and outcomes. (Riebe et al., 2016; Thompson et al., 2021; Tucker & Abbasi, 2015).

In addition, research conducted during the COVID-19 pandemic, which necessitated an abrupt shift to online and hybrid education in universities worldwide for the following two years, underscored the importance of teamwork in design studios, particularly for enhancing students' communication skills and motivation (Fernandes, 2022). Peer assessment within and between groups also supported students' social skills, motivation to learn, and the development of higher-order thinking skills such as critical and independent learning, as evidenced in literature from both before and after the pandemic (Fernandes, 2022; Kocak, 2023). Additionally, it was observed that students' observation and evaluation of each other's work increased their creativity (Kocak, 2023).

One might also question the rationale behind prioritizing the use of timber in this first-year project. Starting in 2020, the Faculty of Architecture and Design at BAU initiated an academic perspective focused on industrial wood and its properties as a sustainable construction material, particularly in terms of its environmental impact, while closely following developments in related construction technologies. Based on the accumulated knowledge in this field, the Timberscapes project was planned as a design-build process utilizing predefined timber components. The next section will elaborate on the motivations for working with timber in the first-year design studio.

Why Timber? Incorporating Timber in Architectural Education

As of 2020, BAU has placed special emphasis on industrial timber and timber technologies, aligning with the United Nations' 2030 Sustainable Development Goals. The aim is to keep timber, which holds a significant place in Istanbul's architectural history, on the academic agenda and integrate it into education to promote a more sustainable and healthy environment in the future. In line with this initiative, efforts are being made to establish a timber technologies workshop at the BAU Kemerburgaz Future Campus. The inclusion of Forest Industry Engineer Demet Sürücü (founder and former coordinator of KUDEB's Timber Training Workshop in the Istanbul Metropolitan Municipality) on the BAU Architecture Department staff has strengthened the focus on timber technologies. This emphasis is reflected in building construction technology courses, the specially developed elective course "Contemporary Timber Buildings and Structural Systems," project studios, and extracurricular activities such as "Timber Talks." Timber Talks is an online event series that brings together a diverse range of experts and professionals—including designers, manufacturers, and technology developers—to present and discuss international developments in timber products and technologies. As a result, students remain informed about advancements and current productions in this field, regardless of their year of study.

The climate crisis is increasingly highlighting the potential of wood as a carbon-emission-reducing and thermally efficient alternative for the construction industry. The preference for industrial timber species such as CLT and glulam over high-carbon-emission reinforced concrete and steel systems is expected to be a significant step forward in achieving the decarbonization target under the 2030 Sustainable Development Goals (Brown & Camilli, 2023). Consequently, wood materials and construction technologies have gained substantial visibility in architectural education, particularly in pedagogies that emphasize the interconnectedness of knowledge and skills, such as design-build and learning-by-doing approaches. Following pioneering examples like the Department of Architecture and Timber Construction (URL 4), established in 2002 at the Technical University of Munich, various architecture schools have started to open wood construction departments. The Center for Wood Innovation at Bern University of Applied Sciences, Architecture, Wood, and Civil Engineering, is exploring new possibilities in architectural education for a sustainable environment (URL 5). In Canada, the newly established McEwen School of Architecture has developed a unique curriculum focusing on the local ecology, resources, and wood production of North America (URL 6).

In addition to institutionally placing timber as the backbone of architecture and design education, many schools of architecture also explore the potential of wood-based materials and industrial timber technologies in studio courses along with construction technology courses. At the Fay Jones School of Architecture and Design at the University of Arkansas, the "Future of Wood" studio exemplifies this approach (Brownell, 2020). Here, fifth-year students constructed buildings they designed using industrial wood materials they developed from wood dust, sawdust, and similar byproducts. At the University of Texas at Austin, in the "Time for Timber" studio, students from the architecture and interior architecture departments focused on developing new formal and performance-based designs that emphasized the material properties of wood and speculated on new timber construction standards (URL 7). In some institutions, design is seamlessly integrated into technology courses. At the School of Architecture and Planning at the University of Auckland, for example, the Timber Technology course involves students in every stage of the construction process. This includes developing the program and constructing a 10 m² structure of their design, intended to provide social benefits (Chapman et al., 2017). Since 2023, the Association of Collegiate Schools of Architecture (ACSA), an international organization, has awarded the "Timber Education Prize" to design studios. This initiative aims to foster greater interest in wood-based products within architectural education and to encourage innovative and sustainable approaches using timber building systems (URL 8).

Nevertheless, it is apparent that the global interest in wood products and industrial timber materials has not been sufficiently integrated into architectural education in Türkiye. This gap is closely related to the 20th-century shift in Türkiye’s building production market, where reinforced concrete—requiring less construction expertise—became dominant, replacing the historically wood-based housing production. Given global trends, high seismic performance and environmental benefits of timber, Türkiye must take steps to reintroduce this material into architectural education. The Timberscapes project seeks to introduce first-year students to timber’s potential, early in their education, encouraging innovative uses of the material in future projects and aligning with the faculty’s broader mission to promote sustainable architectural practices.

Methodology:
This article provides a comprehensive discussion of the studio's methods, including an explanation of the design problem, an overview of the studio content and an examination of the background that led to the development of this topic. It also outlines the pedagogical processes involved in carrying out the project in teams, including the organization of student groups, their assigned tasks, the evaluation of their performance during role changes, and a brief mention of evolving conditions encountered throughout the process. Furthermore, student outputs, images of studio activities, and personal reflections are included to enrich this narrative.

The Design Problem, the Pedagogical Approach and the Studio Content
The Timberscapes project was built upon three main pillars previously outlined as the studio's objectives. Creating a central place for timber in architectural design education aligns with the faculty's mission of acting as a forerunner in promoting sustainable materials in educational design practices, supporting its commitment to the Sustainable Development Goals. The design-build strategy was considered a valuable pedagogical approach to mobilize, inspire and engage first-year students who had recently returned to face-to-face education in the last phase of the pandemic and were just beginning to explore the possibilities of physical interaction in the studio through an immersive design and build process. Teamwork, essential for design-build projects at a 1:1 scale, was also integral to the Timberscapes project, which aimed to instill negotiation and dialogue skills in students—areas often underdeveloped or neglected during online learning.

In team-based studio practices, students are encouraged to view collaboration as a catalyst for creative innovation, recognizing design as a process that integrates diverse knowledge, perspectives, and expertise, rather than being a

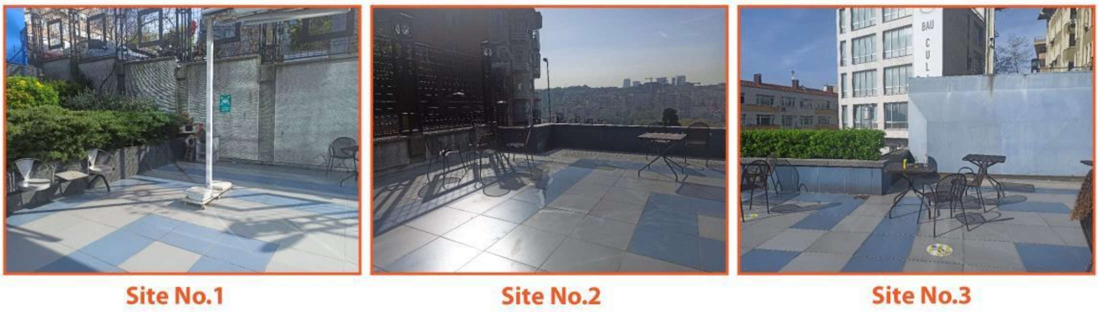

Figure 3: *Three different locations identified on the open terraces of the campus*

purely subjective endeavor (Yair & Press, 2000). Additionally, verbal, digital, and visual tools for articulating and communicating design ideas with peers are pivotal in promoting active learning and skill development (Yair & Press, 2000). Although the advantages of teamwork are widely recognized in the literature, numerous studies highlight the challenges associated with collaborative projects in architectural education, particularly concerning students' experiences and perceptions such as fairness in evaluations, challenges in group formation (e.g., disparities in skill levels or engagement), assignment effectiveness, and the impact of tutor feedback (Riebe et al., 2016; Thompson et al., 2021; Tucker & Abbasi, 2015). In light of these challenges, Thompson et al. (2021) advocate for a shift in educational objectives moving from merely encouraging positive attitudes toward teamwork to cultivating a deeper understanding of its complex and nuanced nature. This shift would emphasize the value of teamwork in fostering a collective spirit, mutual responsibility, and peer support, positioning these qualities as essential learning outcomes in architectural education. Similarly, in the Timberscapes project, it was observed that student collaboration improved throughout the studio process; however, issues such as group formation and the differing skills and perspectives of members continued to cause conflicts.

Returning to the studio content, students were tasked with designing and constructing lightweight timber structures with flexible, adaptable programs for student use, to be situated on the terraces that constitute the limited open spaces on campus. The campus itself is a building originally conceived in the late 1990s as an office complex, featuring vertical circulation and consisting of two 10-story towers located in the densely populated Yıldız district of Beşiktaş, Istanbul. In 2016, BAU leased the building and repurposed it to serve as educational facilities for several academic departments (Figure 3).

The Timberscapes project spanned the final eight weeks of the Spring 2021-2022 semester, serving as the final assignment for the first-year design studio. Studio sessions were held face-to-face, twice a week, for four hours, involving seven sections, each with approximately 13-14 students. The process unfolded in two phases. First, two to three sections were merged to form larger groups, each overseen by 2-3 instructors. This diversity of instruction and the increased number of students fostered a rich environment for generating ideas, encouraging abductive and critical design thinking, and supporting the design process. The expanded group size also provided more options for team formation. During this phase, students formed self-selected teams of three, adhering to the team size limits common in national and international student competitions, developed scenarios, and designed structures for one of three designated sites over five weeks. The phase concluded with a jury evaluation in which students participated, and one project per site was selected.

In the second phase, the studio was restructured into three main groups, each focusing on further

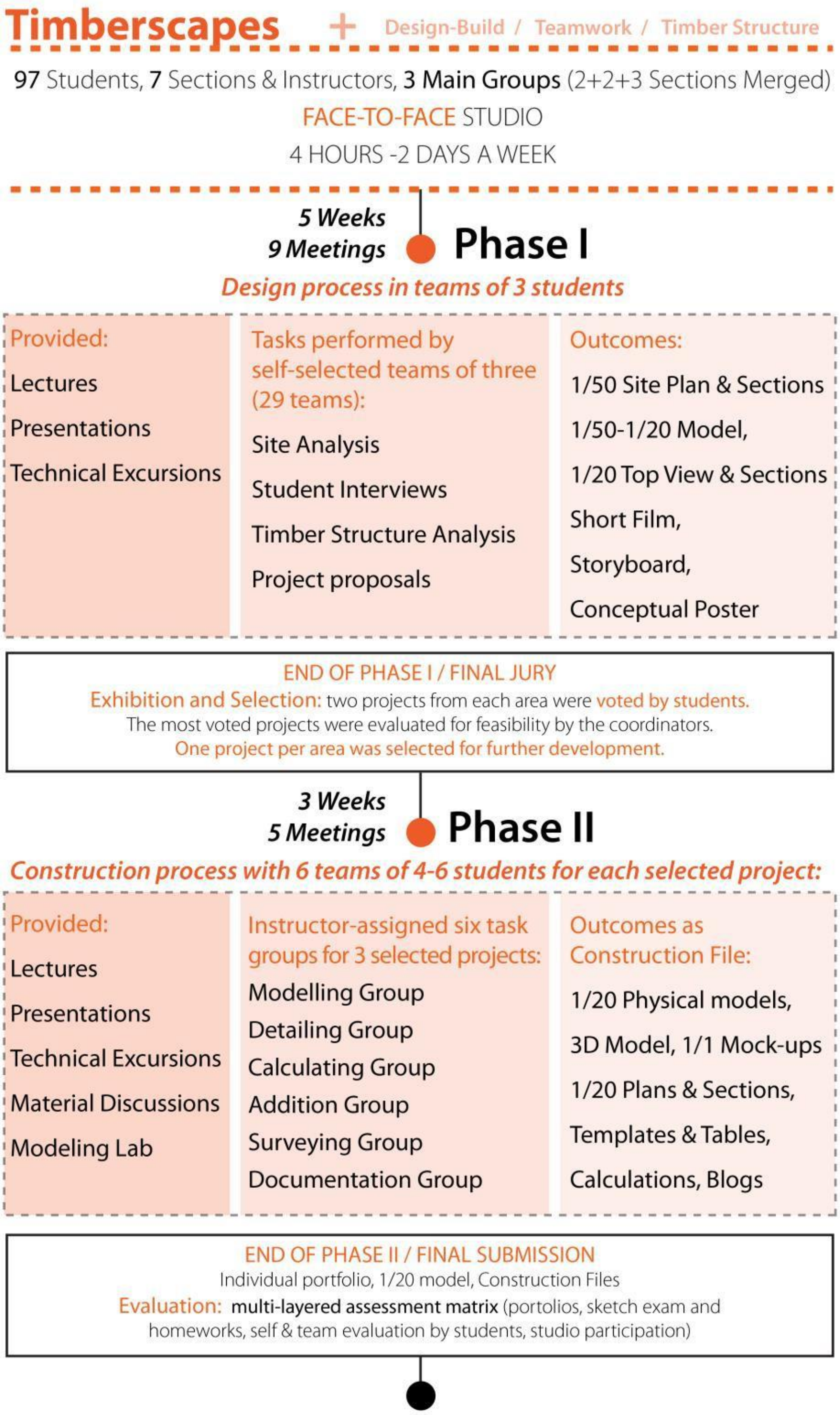

Figure 4: *Organizational diagram of the process*

developing one of the selected projects for the three sites. The projects were refined in greater detail according to six preset tasks, which will be elaborated later. At this stage, instructors assigned teams of 4-6 students to specific tasks for each project. Throughout the process, students engaged in dynamic teamwork, assuming various roles and responsibilities within their groups (Figure 4).

Figure 5: *Photographs from technical excursions*

The Flow of the Timberscapes Project

As outlined above, the Timberscapes project consisted of two phases. In the first phase, the self-selected student teams conducted independent research while participating in seminars and technical excursions. Guest experts were invited to deliver lectures on topics related to the studio problem. For example, architect Mehmet Metin Polat discussed the design and manufacturing process of the timber structure for the main worship space in the Beylikdüzü Fatma Ana Cemevi project, which he designed after winning its design competition. Other guest lectures included Belinda Torus, a BAU faculty member, who spoke on parametric thinking in design, and Demet Sürücü, also a BAU faculty member, who provided examples of contemporary timber construction systems. Technical visits included examining timber construction techniques in the Beylikdüzü Fatma Ana Cemevi's main hall of worship and at various buildings of the Hasanpaşa Gas House Museum (Figure 5). Students also visited a workshop specializing in timber structures, where they closely observed various timber manufacturing details and tools.

During the first two weeks, students selected one of three project locations, interviewed other students on campus to understand their demands and needs, observed the current state of the site, and analyzed their potential for transformation into new spaces with alternative uses and programs for the campus community. They then began developing their proposals based on these defined parameters:

- Must accommodate 5-7 individuals simultaneously.
- Maximum area of 10 m², with a final height of 2.5 m.
- Structural elements made from timber with a maximum length of 300 cm and cross-sections of 5x10 cm, 10x10 cm, 5x5 cm, 2x10 cm, and 2x5 cm; secondary non-structural materials may be proposed.
- Versatile for various purposes and users.
- Portable and self-supporting without permanent fixtures to the ground or walls.

During the design process carried out as teamwork, students produced technical drawings, including models, plans, and sections at scales of 1:50 and 1:20, as well as diagrams, storyboards of building programs, and short videos. This process was supported by active in-studio work and bi-weekly discussions with studio instructors. At the end of five weeks, the first phase concluded with a final jury presentation where all student works were showcased and evaluated. This was followed by a selection process that included peer reviews, allowing students to participate in evaluating their own and peers' work (Figure 6 and 7). During the selection phase, each team of three students displayed their models and drawings in the exhibition area and reviewed their peers' projects. The exhibition, which featured a total of 29 projects, culminated in an online voting process where each student selected their top

Figure 6: *Examples of student work presented for selection at the exhibition*

Figure 7: *Phase one final jury, exhibition, and selection of designs*

two projects for each area. Ultimately, one design from the top three vote-getters in each location was chosen for implementation, based on the feasibility of the structure (Figure 8).

When the second phase of the project started with the selected designs, it became apparent that completing the projects by the end of the semester would not be possible. This was due to the significant discrepancy between initial cost estimates from timber producers and new costs arising from economic fluctuations. Consequently, the decision was made to focus on developing detailed plans and manufacturing projects for future implementation. The scope and content of the second phase were thus redefined. Six task groups for each of the projects were established for this purpose: the Modeling Group was responsible for creating AutoCAD drawings and SketchUp models; the Detailing Group focused on researching and developing structural details, connection profiles, and 1:1 mock-ups; the Measurement Group prepared detailed measurements, survey drawings, and material templates; the Calculation Group handled material quantity and cost calculations; the Addition Group addressed additional materials and design elements such as plants and lighting; and the

Figure 8: *Presentation boards of the three selected designs from phase one*

Documentation Group recorded and shared all design processes. For each of the three projects, the documentation groups started an Instagram account and blog to document and showcase

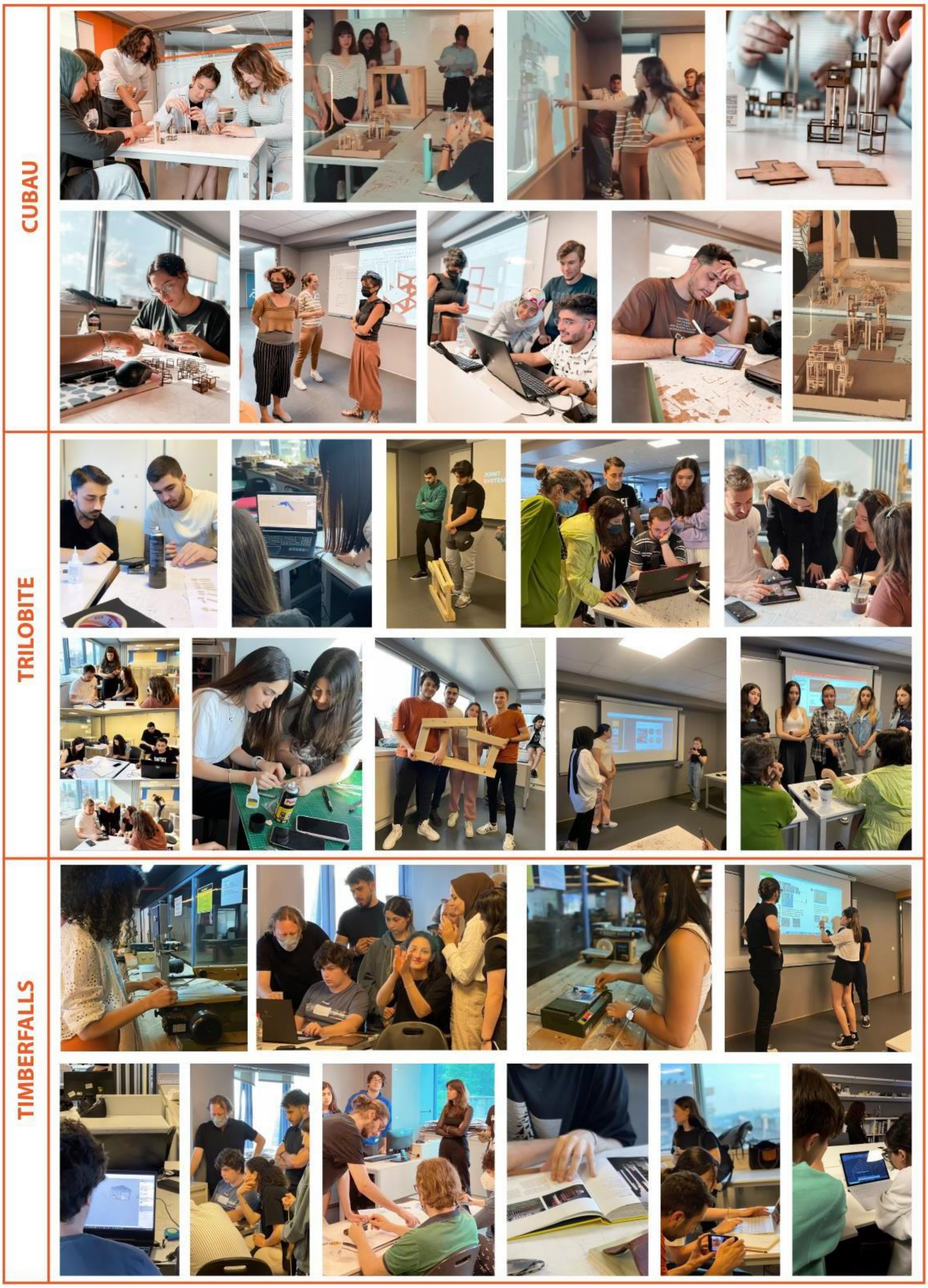

Figure 9: *Instants from the second phase shared by the Documentation Groups' Instagram pages*

their progress (Figure 9). These platforms became crucial for feedback and coordination within the larger team, serving as key tools for tracking work. Members of the teams whose projects were chosen were reassigned to specialized groups focusing on different aspects of the implementation process, fostering effective communication and coordination between the new teams. In contrast to the initial phase, which relied solely on analogue models, the second phase incorporated digital tools such as AutoCAD and SketchUp. The modelling team, now in collaboration with the detailing, measurement, and calculation groups, used these tools to refine the designs. Through practical research and collaborative efforts, the sub-teams identified errors and deficiencies in the cross-sections and material details of the selected projects. They worked together to revise the designs, preserving the core concept while minimizing costs. Highly detailed 1:20 scale models, reflecting the final revisions, were produced to guide the implementation process.

As mentioned above, in the two-phase format of the studio, the initial teams of three members were reorganized, forming new teams with diverse members and new objectives. This restructuring fostered a dynamic environment of dialogue and negotiation, promoting continuous communication within the studio. Throughout the process, students actively utilized the model workshop, where they were offered essential guidance on the use of tools and machines, as well as appropriate modelling and detailing techniques. Demet Sürücü, who introduced timber materials and construction systems at the project's outset, provided ongoing support throughout both project phases. This included assisting with the integration of linear timber elements, detail production, quantity calculation, and budgeting. Thus, over the course of eight weeks, students experienced a collective and participatory design process and gained firsthand experience in a multifaceted project development process that necessitated teamwork and different expertise.

The evaluation and grading of student performances in this process, which relies on different phases and variable group work, is also a significant pedagogical discussion for this project. Consequently, a multi-layered assessment matrix was established to monitor and evaluate both the teams collectively and the individual members within those teams. In addition to the preliminary and final jury evaluations, and the group portfolio for each of the sub-teams and the larger ones, the students were asked to submit an individual portfolio, documenting and self-evaluating their individual participation in their teams (Figure 10). Also, they were requested to evaluate their team members, and these evaluations were included in the grading matrix. Nevertheless, a fair evaluation and assessment of individual performances within such group work proves challenging and necessitates further exploration in future iterations of similar studio projects.

Discussion and conclusion

This studio experience was conceptualized and executed in the post-COVID context of 2022, following extended lockdowns and prolonged periods of isolation for first-year students. The studio problem presented here was developed within this specific context, though a formal framework for evaluating the pedagogical approach was not initially established. As a result, neither the teaching methodology nor the studio outcomes and student responses were assessed through pre-planned surveys. Consequently, this research presents a reflective analysis based on experiential insights, student work, and observations rather than pre-established survey data. Nevertheless, the experience offers valuable outcomes for discussion and future research.

Overall, the project process, structured in two phases, rendered the eight-week duration highly dynamic for both students and studio instructors. The students experienced a productive learning period, engaging in various stages of digital, visual, and verbal communication throughout the design process. During the first phase, they worked in self-selected teams of three, on individual proposals. This evolved into larger, more diverse and instructor-assigned groups in the second phase, focusing on the three selected projects, thus

Figure 10: *Examples from the group portfolios*

fostering a continuous process of teamwork and collaboration in the studio. The selected three projects, originally designed by small groups, were further developed and refined by new, larger groups divided into sub-teams according to predefined tasks. In architectural design studios, students typically concentrate on their individual or team-created designs. This project, however, required them to engage with and contribute to a design that was not originally their own. This unique setup allowed students to embrace and enhance a collaborative design through lively dialogue and negotiation within their assigned roles through multiple team-based activities with changing group size, format and duration. The pedagogical format of the Timberscapes project provided an opportunity for experiencing efficient communication and division of labor within a team, the strategic use of expert support, and the dynamics of architectural teamwork. Furthermore, the entire process exemplified the management phases of implementing an architectural project, integrating experiences of communication, dialogue, problem-solving, and negotiation.

The inability to fully realize the projects, despite the initial design-build conceptions, was a disappointing outcome for both students and instructors. The volatile economic dynamics of the country likely contributed to this result, highlighting the need for meticulous planning of financial resources in future iterations, from the outset. This includes setting material limits as part of the project criteria. Despite the initial disappointment that the projects could not be realized as envisioned, an encouraging outcome emerged: informal feedback indicated that many students who later enrolled in the elective course "ARC2935-Contemporary Timber Buildings and Structural Systems," available to second-year and above students in the 2023-2024 academic year, had previously participated in the Timberscapes project during the spring semester of 2021-22. Their interest in this course, which focuses on industrial timber building materials and construction systems, appears to be strongly influenced by their first-year experiences with the Timberscapes project. Moreover, the planning and evaluation of the design, development, and implementation phases of the design studio projects under discussion, which involve 1:1 scale production through teamwork, demand careful pedagogical consideration. Ensuring that students acquire the necessary knowledge and skills while establishing a fair and objective evaluation process requires thoughtful planning of each phase. This sensitivity is particularly important due to the inherent challenges and complexities in fostering effective group work, a core element of the design-build approach. Research on teamwork pedagogy also reveals the complex, multilayered relationship between team effectiveness, student motivation, and the teaching of teamwork (Tucker & Abbasi, 2015). It is also suggested that an in-depth understanding of what constitutes effective teamwork is critical for designing teaching methods, assignments, and assessment strategies. In terms of the pedagogical impact of the Timberscapes project, student concerns about fairness in the project selection process during the first phase and discrepancies in team member contributions during the second phase were consistent with findings in the existing literature. As stated earlier, the study did not include a structured research design to gather student feedback or assess the design outcomes. Looking ahead, the tutors' observations will play a pivotal role in refining the process, laying the groundwork for a framework for pedagogical evaluation and assessment. This framework will guide the implementation of future iterations of similarly structured projects, ensuring a more informed approach in the coming years.

To conclude, contemporary approaches and methods in design education are diversifying. There is a growing demand for new forms of architectural education that address current social and ecological issues, adapt to changes in information technologies, and foster interdisciplinary knowledge and skills (Hacihasanoglu, 2019; Pasin, 2017; Wang, 2010). Given that architecture increasingly relies on teamwork due to issues of scale, specialization, and ecological concerns—facilitated by advancements in information and production technologies—the importance of collaboration in architectural education will continue to grow. The COVID-19 pandemic, which led nearly all universities in 180 countries to transition to online learning in March 2020, has further expanded the discourse on architectural education to include online and hybrid pedagogies, marking another significant pathway for the future of education. Through reflecting on these evolving educational models and integrating innovative, collaborative and responsive pedagogical approaches, including design and build type hands-on methods, architectural education can better address the complex and dynamic challenges of our built environment and its future.

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"Material !Ndeed" Workshop Series as a Hyper-Focus Niche at the Intersection of Material Selection and Architectural Design Tools

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Abstract: This study examines the "Material !ndeed" workshop series held during the summer semesters of 2021-2022 and 2022-2023 at Özyeğin University's Faculty of Architecture and Design. This research assesses the efficacy of "hyper-focused learning," which prioritizes intensive study on a single topic, compared to "hypo-focused learning," which encompasses multiple topics within the same academic semester. The principal objective is to equip architecture undergraduate students with a comprehensive understanding of architectural sub-specialties through a hyper-focused learning approach. The workshops are designed to enhance students' research skills and ability to apply obtained knowledge to various design fields. The workshops offer a complementary learning experience that strengthens their knowledge generation and sharing skills with peer learning. The Material Indeed workshops are configured as a ten-day practice with the participation of fifteen to thirty students, focusing on systematic material selection methods, building components, elements, and conceptual design processes. The initial workshop served as a pilot study, while the second workshop was designed to facilitate the transfer of scientific knowledge to practical applications regarding pilot study results. During the second workshop, students commence seminars on building materials and representational tools, after which they undertake tasks to research and represent the various properties of building materials employed in exterior wall systems. They conduct tectonic analyses of built examples and develop 1/10 scale exterior wall models, synthesizing their findings into the design process. The workshop methodology is based on Kolb's learning process, which combines passive learning through seminars, active learning through research, and experiential learning through model-making. The study evaluates the impact of the workshops on design education, the hyper-focused learning approach, and the educational methods used. A questionnaire applied to participants led to the formulation of a discussion on the potential of hyper-focused learning, intending to improve the quality of design education.

Keywords: Material, Architectonic, Design education, Hyper-focused learning.

1. Introduction

In contemporary architectural education, the field of building technology and materials is the most substantial complement to design studios, along with theory and practice. Materials and building technology education in architecture aims to equip students with the capacity to devise innovative solutions to performance-based design challenges. Additionally, it should facilitate an understanding of the interrelationship between conceptualization, structure-aware proposals, and materiality by integrating tectonic design approaches. Finally, it should enable the realization of the designed structures. (UNESCO-UIA, 2017). As Simon (1973) asserts, by framing the ill-defined design problem in terms of sub-problems that correspond to courses designed within the framework of building engineering and materials science, it is possible for architecture students to transfer the knowledge they have acquired in this area to the architectural design studio (Banerjee & Graaf, 1996). However, the ratio of building engineering and materials science courses to all courses varies between 10.81% and 0.76% in universities located in Turkey. (Çakmak & Akıner, 2021). Besides, most architectural design students prefer to choose from materials they already know rather than conducting a systematic material research and selection process in their design proposals. (Koyaz & Altun, 2015). Furthermore, building technologies and materials courses, which have a comprehensive course load, play an important role, especially in understanding, explaining, and interpreting building tectonics. (Guzelcoban Mayuk & Coşgun, 2020). Considering the considerations mentioned above, it is evident that equipping students with a novel, diversified learning experience that prioritizes material selection and construction technologies represents a significant undertaking in pursuing an efficaciously integrated pedagogical framework. It is therefore assumed that students will develop the capacity to analyze and apply the relations between design, structure, and construction with the help of architectonic tools, thereby enhancing their competencies in producing, transferring, and problem-solving knowledge. In this context, the study focuses on the "Material !ndeed" workshop series, designed as an informal learning niche during the summer semesters of 21-22 and 22-23 within the scope of Özyeğin University Faculty of Architecture and Design Research Internships. The research investigates the effectiveness of "hyper-focused learning" processes, an alternative to "hypo-focused learning," on material selection and its possible contributions to architectural education. The term "hypo-focused learning" refers to a learning process divided to facilitate learning more than one specialized subject in a given period of time. In contrast, "hyper-focused learning" refers to an in-depth study and concentration on a specific subject. In this context, conventional architectural education, which is divided into semesters within the scope of the curriculum and in which different courses on more than one subject are programmed, exemplifies "hypo-focused learning." In contrast, workshops, designed for a shorter period than the semesters of education, align with "hyper-focused learning" processes. The Material !ndeed Workshop series is a ten-day program for fifteen to thirty architecture students during the summer semesters. Its objective is to impart detailed knowledge and experience in building technology and materials to students through diverse educational methodologies. The objective of the workshop is to improve the transfer of knowledge between the processes of designing building elements and conceptualizing designs. This is achieved by enabling students to systematically advance the material selection process in the context of design decisions at different scales. By focusing on building materials, the workshop facilitates discussion of the concepts of performance, aesthetics, and applicability in building design through architectonic tools.

The workshop series is designed as a highly specialized learning environment where theoretical and empirical knowledge is transferred to students through passive and active learning methods. The first workshop of the series was designed as a pilot study. Based on the pilot study's findings, the second workshop was refined to enhance the integration of scientific and empirical knowledge and its application in architectural practice. The workshop employs a combination of passive and active learning techniques. Passive learning methods include seminars on theoretical knowledge, while active learning involves research, analysis, representation, and model production.

In this context, the concepts of materials, components, elements, and systems are viewed as integral to architectural design. The goal is to enhance the students' capacity to employ an interdisciplinary design approach. The active learning structure of the workshop was developed based on the learning-by-doing method and the theory of experiential learning (Dewey, 1938; D. A. Kolb & Kolb, 2013). This approach enabled students to gain theoretical and empirical knowledge in architectural practice through hands-on experience. As the final phase of the study, a survey was conducted to assess the skills and competencies acquired by the workshop participants due to the hyper-focused learning process implemented within the Material Indeed Workshop Series. The survey results were analyzed to optimize the hyper-focused learning approach. Consequently, the potential of the hyper-focused learning process and its contributions to design education are open to discussion, and the roadmap developed is intended to serve as a guide for all actors aiming to improve the quality of design education.

1.2. Approaches in Architecture Education and Workshops as A Hyperfocus Niche

The term "architectural education" can be defined as a process through which theoretical and experience-oriented knowledge is imparted to students through various learning methods. This process provides the conditions for interdisciplinary production in diverse contexts, scales, and environments. It necessitates the integration of multiple actors and parameters, and most crucially, it emphasizes the act of creation and making. In this regard, architectural education requires a configuration that aligns with a dynamic learning state comprising cognitive processes such as understanding, interpretation, and production. Dynamic learning also establishes a connection between diverse types of information (Hollingworth, 1932). This connection can be defined as a multi-step process that reveals the embedded relationships between design processes with different ontological structures and thus accelerates the discovery of new relationships that go unnoticed in the design process. This discovery also corresponds to a proactive cognitive process that triggers critical and creative "design thinking" (Cross, 2011).

However, when considered holistically, design can be defined as an ill-defined problem with ambiguous relationships. This ambiguity can stimulate positive creative thinking (Eastman, 2001; Reitmann et al., 1964; Simon, 1973). This approach is particularly beneficial for novice designers, as it allows them to address complex problems in a structured manner, facilitating the effective transfer of knowledge acquired at different stages of the design process to the subsequent stage. With that aspect, workshops are an effective method for addressing a specific topic that plays a significant role in design processes in detail and creating an effective informal educational environment that develops students' problem-solving competencies at different levels (Güzelçoban, Mayuk & Coşgun, 2020).

Workshops, part of informal education, are also defined as alternative environments where experiential learning methods can be applied (Roberts, 2012). Experiential learning includes acquiring concrete knowledge through new experiences, asking questions about the experience gained through reflective observation and discussing the experience, establishing relationships by conceptualizing knowledge and experiences, and conducting active experiments through physical modeling and prototyping (D. Kolb & Fry, 1973). At this point, learning by doing emerges as an important part of the experiential learning process. Learning by doing can be perceived as neither a simulation of professional architecture nor a direct application of theoretical knowledge in the field, with its own tools and learning outcomes (Gür & Yüncü, 2010). Learning by doing is based on the internalization of the passively acquired knowledge object by the learning subject through experiences (Dewey, 1986). At this point, learning by doing is a proactive method that enables the construction of the cycle of meaning and explanation in the hermeneutic context for the subject who is in the act of learning by building links between concepts (Ricoeur, 1998) and the transformation of data and information into knowledge that can be processed and internalized by the learner. In addition, learning by doing is defined as a set of processes that create opportunities for the learner to acquire knowledge while solving a problem (Anzai & Simon, 1979). In architectural design processes, learning by doing can be defined as representing the data obtained with diagrams, mind maps and sketches that define relationships at the conceptual level, field trips, 3D models and/or digital models and 3D representations and solving a well-defined design problem. At this point, learning-by-doing and experiential learning approaches are very suitable for gaining competence in a specialized subject, solving different design problems, and establishing an effective hyper-focused learning process. However, the process of learning by doing can become a trigger for "doing without learning" as it creates much cognitive load for the student (Roberts, 2012). According to the cognitive load theory, learners can only retain a certain amount of information in their memory during the experience. Therefore, the learning process should be optimized, and the learner's mind should be freed from additional cognitive load and focus only on the necessary experiences (Sweller et al., 1998). At this point, it is estimated that advancing experiential learning processes in a hyper-focused state and supporting them with passive learning methods in which theoretical prior knowledge is conveyed will enable students to have a more efficient learning experience. In this context, Material !ndeed Workshop Series has been designed within a hybrid educational approach that supports the learning-by-doing process with passive learning modules. Thus, it aims to provide students with detailed theoretical and practical knowledge in material selection and building technology from a holistic perspective.

1.3. Material Selection in Architecture

In architecture, the material can be defined as a constitutive element that acts as a bridge between design processes and construction processes, determines the tectonic properties of the building, and ensures that the components and elements of the building are constructed according to the user function and environmental conditions. The fulfillment of the performance criteria determined in the design process can be realized by correctly determining the physical equivalents of the architectonic compositions corresponding to these criteria (Fernandez, 2005). Building materials fulfill different functions in layering with various physical, mechanical, chemical, optical, technological, biological, dimensional, and sensory properties. However, to select the appropriate material for the building components, it is necessary to integrate a systematic selection strategy that covers the scale of the building and building elements into the design process.

When material selection approaches are classified according to architectural, industrial design/engineering and environmental impact perspectives, Balanlı, Japanese Reserach Group, Lohaus and Steinborn, Müller, Cronberg, Sneck Approaches are defined as material selection criteria with an architectural perspective (Koyaz & Altun, 2015).

Although these approaches address material properties at different levels in the context of performance criteria determined considering environmental effects, the location, function, and user characteristics of the building, determining the behavior expected from the material according to different scales has been a common criterion for all approaches. For this reason, it is impossible to advance material selection independently of the building element, structural system design, and the conceptual design process of the building. Material !ndeed Workshop Series has addressed material selection processes as inter-scalar tectonic research to provide students with better comprehension.

2. Method

The Material !ndeed Workshop Series was conducted during the summer semesters of 21-22 and 22-23 as part of Özyeğin University Faculty of Architecture Research Internships. A total of twenty-seven and fourteen undergraduate architecture students, respectively, participated in the series. The workshop's objective is to equip participants with the competencies and skills necessary to translate theoretical knowledge into practice, to access data on building materials through scientific research methods, and to analyze these data comparatively with architectural representation tools. Additionally, the workshop aims to facilitate an understanding of the structures built with a focus on building materials through architectonic tools and to construct inter-scale relationships. In this context, the workshop employs a hybrid approach that combines passive and active learning modules, as explained by (D. Kolb & Fry, 1973). The preliminary workshop of the series served as a pilot study, while the second workshop represents the developed output of the hybrid educational approach. The study workflow is explained in the diagram below.

The method of the study was mainly configured according to the steps of the proposed hyper-focused learning approach. The physical modeling phase was applied to the second workshop as the main case study.

3. Material !Ndeed Workshop Series

3.1 Pilot Study

The pilot study was continued with twenty-seven undergraduate students during the Summer Semester of 2021-2022. Its focus was on the exterior cladding materials used in the building envelope. In this context, the workshop commenced with theoretical presentations on the role of materials in architectural design, the classification and properties of materials, and architectural expression techniques. Subsequently, each student was assigned the cladding materials identified by the instructors. They were then required to contact the

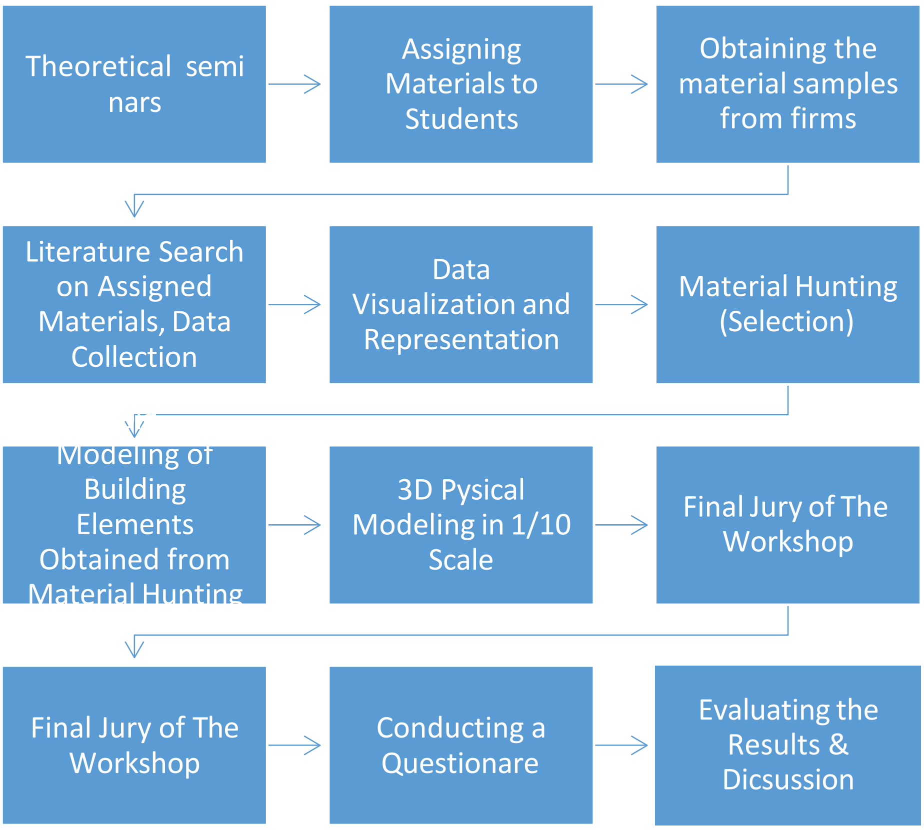
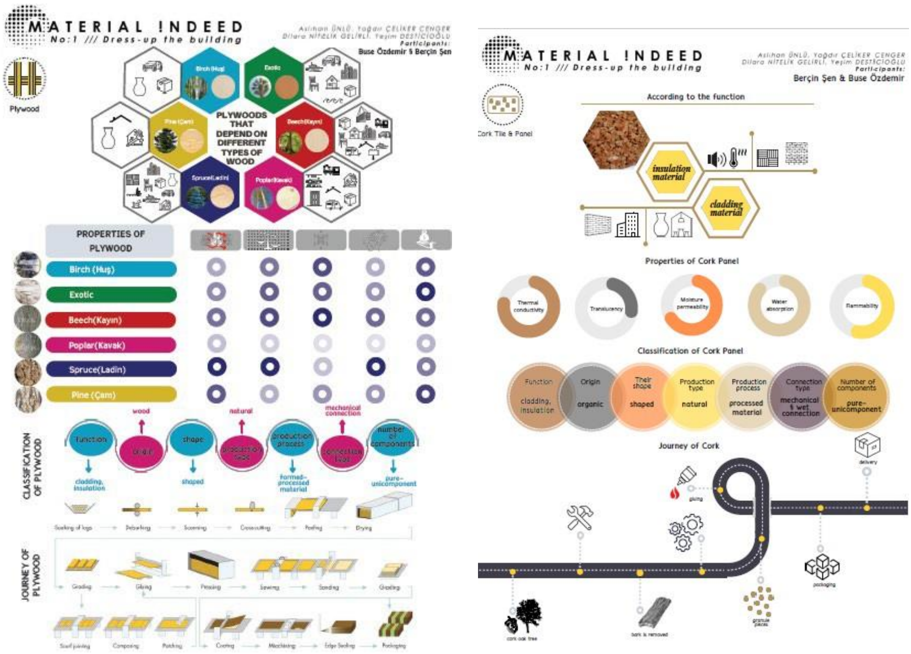


Figure. 1: *Workflow illustrates the method of the study*

Figure 2: *Material Samples Obtained During the Research*

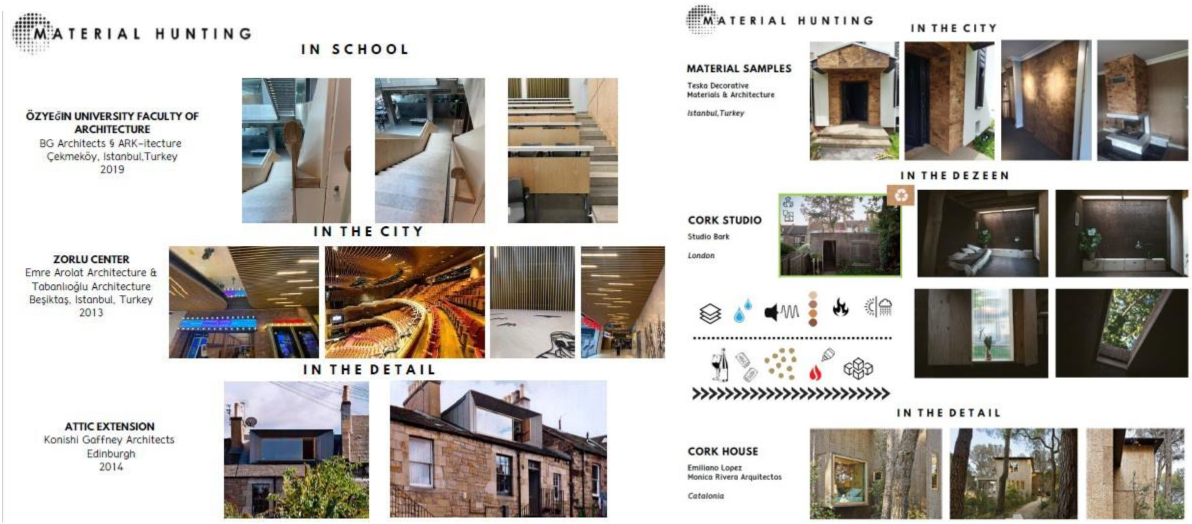
manufacturers of the assigned materials and obtain samples (Figure 2).

The workshop proceeded with a comprehensive analysis of the available literature and data collection from the samples of material obtained. The work was conducted in two groups to enable the students to transfer their knowledge to one another. A practical training session on using digital libraries was conducted to enhance the efficacy of the data collection procedure. Leveraging digital library resources and digital material databases, students conducted a literature search on the properties, production process, and application techniques of their assigned materials. They then analyzed these findings compared to visual and written representations, aligning them with their theoretical understanding of narrative techniques and their prior experiences with narrative techniques (Figure 3).



(a) (b)

Figure 3: *Building Materials Data Collection and Analysis Process (a) Plywood, (Student1). (b) Cork Panel, (Student 2).*



(a) (b)

Figure 4: *Building Materials Data Collection and Visualization Process (a) Plywood, (Student 1). (b) Cork Panel, (Student 2).*

In addition to researching material properties and construction processes, students went on a material hunt (selection) as a gamified research step. They used their assigned materials to examine the buildings built in the city, on campus, and in Detail magazine. Thus, they had the opportunity to explore the different uses, application methods and techniques, and visual effects of materials through built examples (Figure 4).

The final step of the workshop involved an architectonic study of the relationship between the researched materials and building element layering. In this context, students execute material hunting (selection) based on built examples in Detail Magazine, and these selected built examples were modeled as 3D tectonic digital models. (Figure 5). The objective was to provide information based on practical experience regarding the assembly-aware information of the materials and their alternative functions beyond their exterior cladding function. The students are expected to better understand the interrelationship between design and construction by experiencing the construction process in different design mediums.

(a) (b)

Figure 5: *3D Digital Tectonic Model Production.*
(a) Cork panel, (Student 1) (b) ETFE, (Student 3)

As a result of the research and studies conducted within the scope of the workshop, the following conclusions were listed.

- Theoretical explanations accelerated the experiential learning processes and supported the systematic material research process.
- The material hunt (selection) at the urban and campus scales did not meet the expected learning outcomes for all workshop participants due to the lack of some of the materials searched for. However, the material hunt (selection) through Detail magazine contributed more, allowing for analyzing tectonic relationships across scales through built examples.
- During the digital tectonic modeling process, most of the workshop participants had limited knowledge of using 3D digital modeling tools, which required the support of the instructors. For this reason, the participants could not experience the principles of construction and the inter-scalar design process at the targeted level. For this reason, a physical model study using realistic materials is thought to increase students' building knowledge and make experience-oriented learning processes more effective.

3.2. Main Study: Material !Ndeed 2

The second of the Material !ndeed workshop series was designed based on the pilot study results and was conducted with 14 students during the summer semester 22-23. Based on the pilot study's experiences, the workshop structure was improved by making the following modifications.

- Material hunting (selection) in the city and on campus was not included in the second workshop due to the inefficiencies identified during the pilot study.
- Generic layering exercise, 3d Digital models, and 1/10 scale physical building element models were included in the workshop's scope. Thus, the participants could experience the construction processes at different scales and the 3D digital tectonic model.

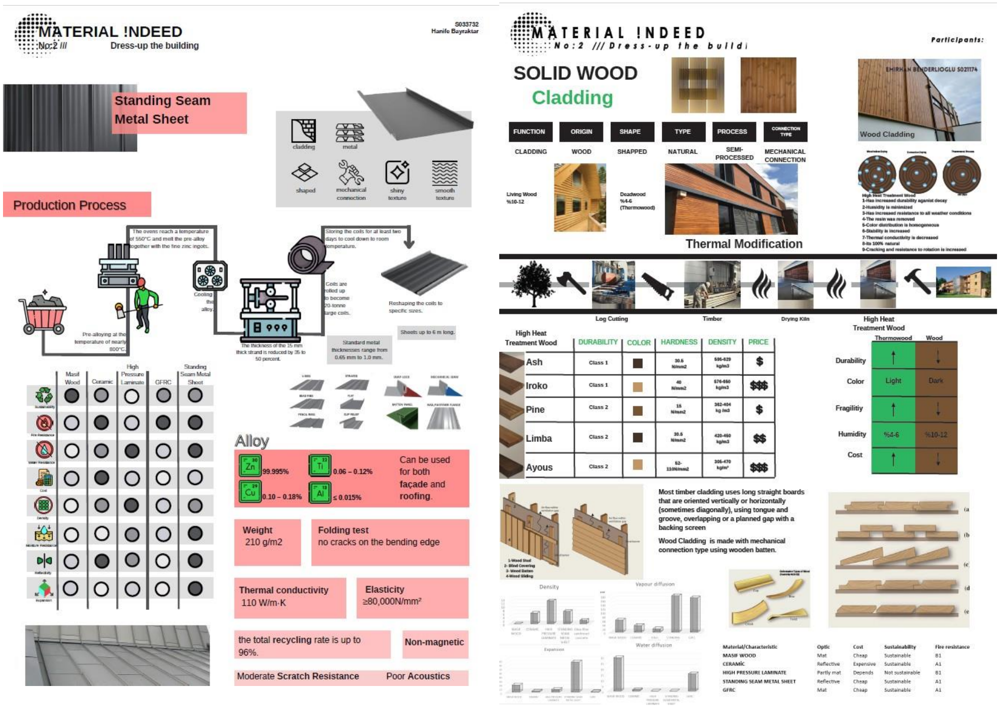
Based on the developments described above, the second workshop in the series focused on the generic layers that create the exterior wall, namely the core, insulation, and cladding materials. Thus, the architectural relationships between the material and the building element were considered holistically (Figure 1).

Following the introductory phase of the theoretical seminars, the materials were assigned to the students regarding material origin and function (i.e., core, insulation, cladding). In this context, assigned materials were analyzed according to their origin, such as mineral-based, terracotta, polymer, composite, metal, and wood-based materials. Besides, distinctive material properties were also investigated for better comprehension of material behavior. Afterward, all students continue with model production to execute hands-on building element design. This approach aimed to provide students with a comprehensive understanding of the tectonic design and construction processes, considering the material origins and functions. (Table 1).

Table 1: *Materials assigned to students in the workshop according to their origin and functions*

Assigned Material	Origin	Function
Glass Fiber Reinforced Concrete	Composite	Cladding
Standing Seam Metal Sheet	Metal	Cladding
Natural Wood Sliding	Wood	Cladding
Ceramic	Clay Based	Cladding
Compact Laminated Panel	Composite	Cladding
Perforated Brick	Clay Based	CORE (BONDED)

Aerated Concrete Block	Mineral Based	CORE (BONDED)
Steel Profile	Metal	CORE (SKELETON)
Natural Wood Stud	Wood	CORE (SKELETON)
Aluminum Sandwich Panel	Composite	CORE(PANEL)
Rock Wool/Glass Wool	Mineral Based	Thermal Insulation
EPS/XPS	Polymer	Thermal Insulation
Wood Wool	Composite	Thermal Insulation
Glass Foam	Glass	Thermal Insulation

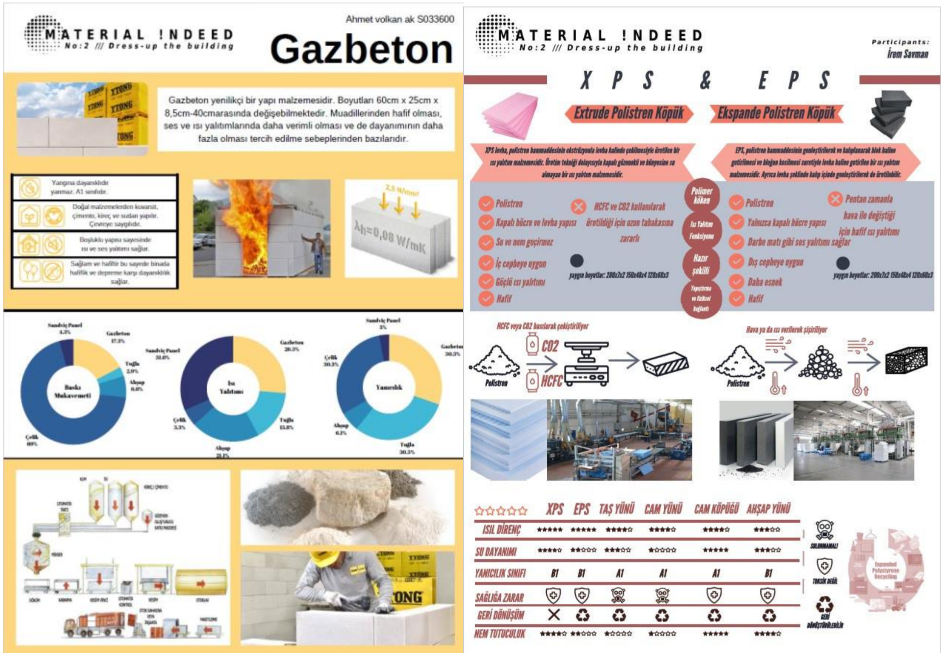


(a) (b)

Figure 6: *Building Materials Data Collection and Analysis Process (a) Standing seam metal plate, (Student 4) (b) Natural Wood Sliding, (Student 5).*

Students researched the properties and production processes of the material in Table 1 and analyzed the obtained data from the literature search using architectural representation tools (Figure 6 and Figure (7)).

Following the material analysis, the students conducted a material hunting (selection) in Detail Magazine. The students focused on selecting a built example of which their assigned materials were used. They examined the relationship between the material and other components in detailing scale according to 2D system sections and written information. They also discussed the relationship between material performance and building element performance within the scope of the workshop. Afterward, students produced three-dimensional digital models of exterior wall systems based on the



(a) (b)

Figure 7: *Data Collection and Analysis (a) Aerated concrete block, Student 7 (b) XPS/EPS, Student 8.*

(a) (b)

Figure 8: *Material hunting (selection) and 3D digital tectonic modeling in Detail Magazine (a) Natural wood sliding, (Student 5). (b) Rockwool, (Student 6), based on digital production.*

built examples selected from Detail Magazine (Figure 8).

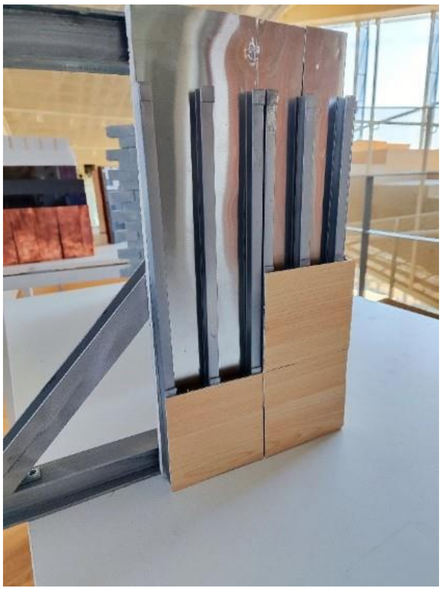
Following the digital tectonic modeling, the materials were allocated to the students according to their function and origin, and

Table 2: *Material Matching for Model Production Process*

Groups	**Coating**	**Body**	**Insulation**
Group 1	Standing Seam Metal Sheet	Aerated Concrete	Glass Foam
Group 2	Compact Laminate Panel	Steel Profile Sandwich Panel	*No additional insulation material is assigned since the sandwich panel contains an insulating layer.*
Group 3	Solid Wood Board	Solid Wood Strut	Rock Wool/Glass Wool
Group 4	Ceramic	Perforated Brick	Wood Wool
Group 5	Glass Fiber Doped Concrete	Aerated Concrete	XPS/EPS

working groups were formed for physical model production (Table 2).

According to research and analyses conducted in previous steps, students began to develop their own building element layering composition as a part of a tectonic design proposal based on selected built examples from Detail Magazine. The tectonic design proposal was executed considering principles of performance-based building element design. During the tectonic design process, the "reflective teaching/learning" approach developed by Schön for design education was preferred as the main educational approach (Schön, 1983). In this way, it aimed to enable students to produce creative solutions by utilizing the knowledge based on their experience gained in previous workshop phases. In this context, the design problem was defined as developing an exterior wall system that will meet the structural, thermal, water, moisture, sound, fire, and visual performances regarding Istanbul's climate. Although the properties of the materials meet some of these performances, substructure design and suggestions about additional insulation layers were expected to be determined by the students to ensure all performances. Furthermore, tectonic physical models were made with realistic materials. Thus, the structural performance of the proposed wall systems could be directly experienced, which refers to the learning-by-doing approach. In contrast, other performance requirements were reflected in the design proposals and model productions with respect to information gained from the theoretical seminars (Figure 9 and Figure 10).



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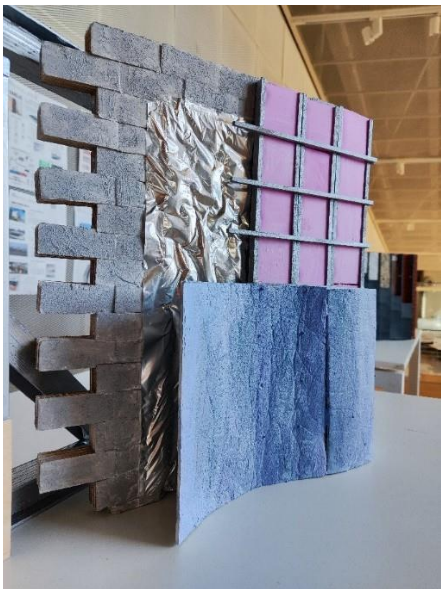

(c) (d)

Figure 9: *Tectonic model production on a 1/10 scale, (a) Group 1, (b) Group 2, (c) Group 4, (d) Group 5.*

The workshop concluded with a final jury to assess the entire process with the workshop participants. A survey was held to evaluate the students' experience of hyper-focused learning, including passive and active learning methods.

5. The Impact of the Hyperfocused Learning Approach on Material Selection and Tectonic Design Processes

A survey was conducted with 14 students who participated in the Material !ndeed 2 Workshop to determine the factors involved in the material selection process and its impact on architectural education. The results are evaluated below.

Considering the educational level of the participants, it is seen that 50% of the participants completed 1st grade, 35.7% 2nd grade, and 14.3% 3rd grade. Students currently in the 4th grade did not participate in the workshop.

- **From which sources do you use to select material in the architectural design process?**

The participants' most preferred sources for literature reviews and material research were websites with material catalogs, with a rate of 92%. Contrastingly, expert opinion was determined to be the least preferred source.

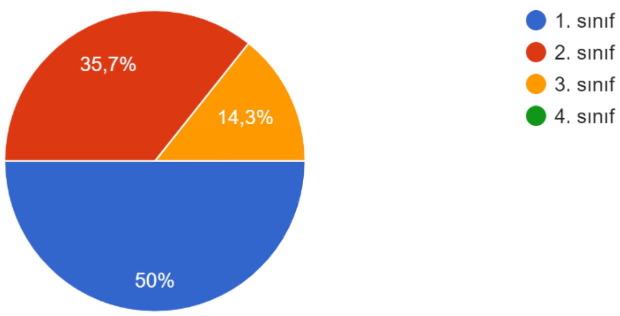

Figure 10: *Questionnaire results*

The survey then continued with the following questions to understand the impact of the students' work on their material selection process. The survey questions were formulated by considering the workshop steps.

- **The factors that play a role in material selection are listed below. Please select the factors that you think you have information about.**

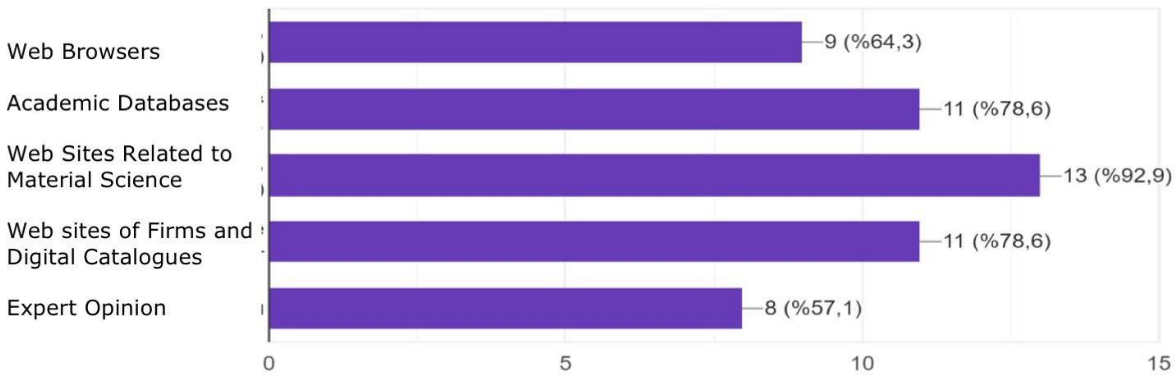

Figure 11: *Questionnaire results*

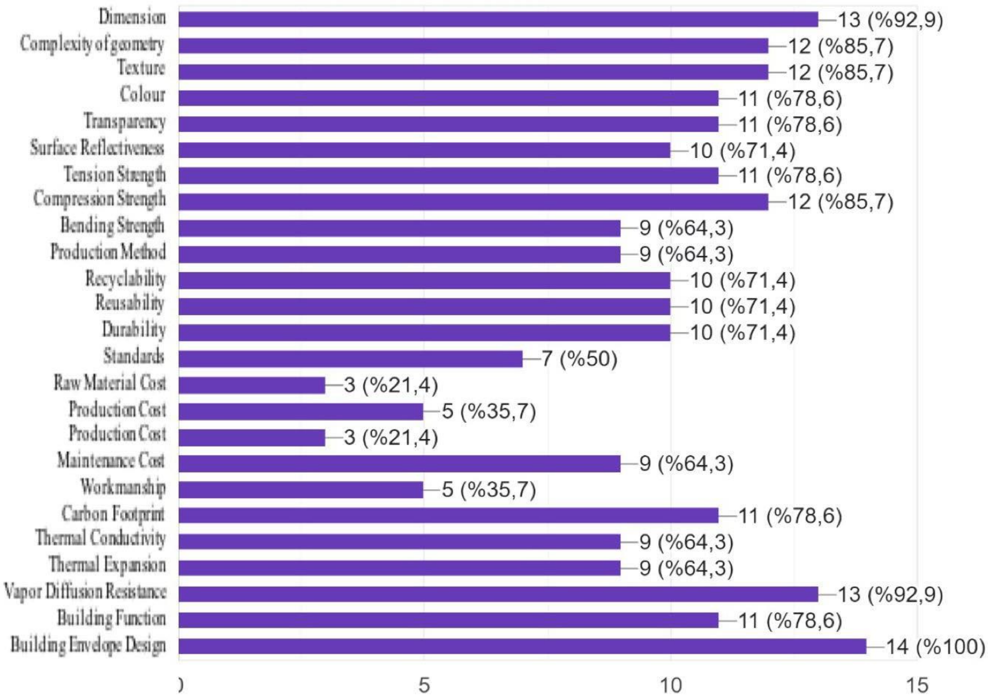

Figure 12: *Questionnaire results*

This question aims to assess the efficacy of the theoretical seminars. All participants indicated that they possessed knowledge of building envelope design, and 92% demonstrated familiarity with dimensional properties. The areas where the lowest proportion of participants reported confidence were raw material and maintenance costs, at 21%.

Please mark how much you agree with the following statements about the research internship (1: strongly disagree, 2: disagree, 3: undecided, 4: agree, 5: strongly agree)

- **Obtaining material samples and technical information from companies played an effective role in my understanding of the material.**

85% of the participants stated that providing samples played an effective role in understanding the material. 7% of the participants were undecided, while 7% thought providing samples was ineffective.

- **Physical contact with the material helped me to conduct my research effectively.**

85% of the participants stated that physical contact with the material helped their research process, while 7% were undecided.

- **The theoretical seminars presented by the instructors during the research internship were useful and supported my material research.**

92% of the participants stated that the theoretical seminars were useful, while 7% were undecided.

- **I can conduct a detailed literature search using scientific methods.**

92% of the participants stated they could conduct detailed research using scientific methods, while 7% were undecided.

- **I can interpret the data from this detailed literature research holistically.**

A total of 92% of the participants indicated that they were able to interpret the data holistically, while 7% of them expressed uncertainty about this proposition.

- **Because we summarize the data by visualizing it, I can interpret the data holistically.**

92% of the participants stated that visualization was effective in interpreting the data holistically, while 7% were undecided about the proposition.

- **I was able to interpret the data holistically because my groupmates and I analyzed the data comparatively.**

While 28% of the participants strongly agreed that the way to interpret data as a meaningful whole is to analyze data comparatively through group work, 35% disagreed with this statement, and 14% were undecided.

- **Making 3D digital models of built examples obtained from Detail Magazine played a role in my understanding of the relationships between materials, components, building elements, and buildings.**

While most participants stated that the sample projects effectively understood the relationships between materials, components, and building elements, 7% of students disagreed.

- **Making 3D physical models using our materials played a role in my understanding of the relationships between materials, components, building elements, and buildings.**

All participants indicated that the model-making process was an essential tool in enhancing understanding of the interrelationships between materials, components, and building elements.

- **Individual studies were quite instructive and beneficial for me.**
- **Group studies were quite instructive and beneficial for me.**

Regarding the instructiveness of individual and group work, 92% of the participants indicated that individual work was instructive and beneficial, whereas only 42% of the students stated group work to be useful.

- **The duration of the workshop was sufficient for the program.**

93% of the participants thought the workshop duration was compatible with the program. Additionally, all participants agreed that the workshop improved their competencies in understanding the relationships between design processes at different scales and between design and construction. In addition, the participants stated that the workshop allowed them to elaborate on the design proposals they developed.

- **I gained the foresight to select appropriate materials in the design process for my future architecture project courses through the experience I obtained during the workshop.**

While approximately 85% of the participants stated that the workshop gave them the foresight to select materials for their architectural design projects, 14% were undecided.

All in all, most of the students agreed that the workshop was highly productive, using passive and active learning methods with hyper-focused tasks. The students indicated they could easily transfer their theoretical knowledge into practical reasoning processes to achieve systematic material selection for performance-based tectonic design.

Discussion and Conclusion

The Material !ndeed Workshop series, which was conducted during the Summer Semesters 21-22 and 22-23 within the scope of Özyeğin University Faculty of Architecture Research Internships, aims to introduce scientific research methods to architecture students, as well as to provide them with the ability to make a systematic material selection and the competence to apply inter-scalar architectonic design approaches in design studios. In order to achieve the targeted learning outcomes, the workshop is designed with a hyper-focused hybrid educational approach that includes active and passive learning methods. The effectiveness of the proposed approach was evaluated through the outputs of the workshop participants and a questionnaire. Considering the evaluated results, possible contributions to architectural education and future studies on the subject were discussed, and the study's main results are explained below.

Hyper-focused learning is a very efficient approach to providing students with competence in technical subjects in architectural education, especially in materials science and building technology fields. The study shows that active and passive learning methods should be used together to increase the effectiveness of the hyper-focused learning approach in material selection and construction technology. The passive learning method is assumed to indirectly support students in executing effective material selections and transferring obtained information to architectonic design approaches in architectural design studios. Passive learning methods also enhance the efficiency of active learning processes by transferring substantial theoretical knowledge on scientific research methods and tools, architectural material properties and classification systematics, data representation, and analysis methods. However, it is essential that passive learning remains a complementary component that supports active learning instead of interrupting the design thinking process by overloading theoretical information to students that could not directly relate to the hands-on experience. To reduce the cognitive load on the student, passive learning inputs should be conveyed in a concentrated, context-based format focused on the study's specific outcome. Thus, it is thought that cognitive capacity can be reserved for the active and experiential learning process. To increase the efficiency of the experiential learning process, ill-defined design problems should be divided into well-defined sub-problems, and the sub-problem definitions should be elaborated and explicit. Thus, it is believed that the learning-by-doing process will progress much more adequately by leaving the creative production variables at the student's initiative during the experience. Compared to digital model production, architectonic model production is more suitable for establishing the relationships between material, component, and element concepts and understanding and applying performance-based building element design principles and construction methods and techniques.

In line with the results summarized above, it is believed that supporting building technology courses, which are a part of formal architectural education, with modules designed within the framework of a hyper-focused education approach, will increase the rate of experience-based knowledge acquisition of students and transfer their knowledge to architectural design studios much more successfully. In this context, the aim is to diversify this study in the future through hyper-oriented education modules focusing on different topics in building technology. It is also planned to expand the sample space by optimizing the executed questionnaire by applying it to more students and conducting a protocol analysis study with a certain number of workshop participants to analyze hyper-focused learning processes elaborately.

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Starting in the Middle: A Method Trial

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Abstract: In the MIM121 Architectural Design I "Starting in the Middle" studio group, which we conducted in the 2023-2024 fall semester at Gebze Technical University, we aimed to question how architecture establishes and transforms the relations between human and non-human worlds under the theme "Umwelt: Building a World". For this, we have adopted Deleuze and Guattari's rhizomatic idea of "being in the middle/starting in the middle" as the studio's processing method and Baruch Spinoza's idea of "being the source of virtuous effects" as our way of acting. We have determined the German biologist Jakob Johann von Uexküll's concept of Umwelt as the theme, considering that the effort to understand the worlds of other living beings we share our environment with has not only a biological or architectural but also an ethical/political side. Uexküll's concept of environment-world (Umwelt), which examines the behavior of animals in the environments they live in, positions itself against the objective, homogeneous and human-centered view of space by arguing that each living thing has its own spatio-temporal understanding and meaning-making process. This concept lays the groundwork for evaluating space as a subjective, multi-agent, heterogeneous sum of pluralities. Within the scope of this article, we document and analyze the syllabus of the MIM121 Architectural Design I studio group from the specific perspective and method of the studio. In doing so, we rely on the results of the 2015 "Architecture Schools First Year Studio Meeting II" workshop. Ten years after this workshop, which revealed the problems and goals of first-year architecture studios on a national scale, we are analyzing our own studio in the context of the workshop's outputs, and we are considering making a contribution to these outputs. Thus, we hope that by discussing the limits, opportunities and threats of the proposed methodology, it will provide a basis for similar studios.

Keywords: Architectural design studio, Experimental pedagogy, Participatory pedagogy, Constructivist learning theory, Sustainability

1. Introduction

In the 21st century's era of crises, we are living in a period in which we are questioning the way we exist in the world as human beings and the relationship we have established with the earth. On the one hand, while technological changes continue, on the other hand, the traces left by humans on the earth are deepening. In addition to events that create large-scale impacts such as global warming and environmental pollution due to the climate crisis, we face problems such as increasing microplastic wastes in the seas, hazardous chemical accumulation in the soil, and loss of biodiversity. On the other hand, we face global crises such as wars, pandemics, large-scale migration movements, food insecurity and housing instability, fake news and rising digital fascism. In Turkey, an unlawful state of emergency following the coup attempt, out-of-control inflation and housing crisis, earthquakes and other man-made disasters are manifesting themselves. In the current conditions, we believe that the architectural design studio should both offer hope by opening a safe space and undertake a mission to develop new ways of relating to the world in the age of crises by teaching critical thinking. For this reason, in the MIM121 Architectural Design I "Starting in the Middle" studio group that we conducted in the fall semester of 2023-2024; we tried to create an environment of production that seeks new ways of relating to the world by being aware of the economic, technological, sociological and political changes in the current period, and tries to discover the potential of architecture to establish relations between human and non-human worlds. In doing so, instead of presenting a linear path with precise definitions, we have followed a path that makes the beginning a continuous action, critical, experiential and moving towards the unknown. In the second section titled "Architectural Design Education and Studio Pedagogy", we dive into contemporary design education and pedagogy literature and question the place of the method we follow in this literature. In the third section, "We Have a Problem and Mapping of Mappings", we mapping the results of the workshop "Meeting of First Year Studios of Architecture Schools II" which was held in 2015 in Istanbul and attended by 31 coordinators and 10 students from different architecture schools in Turkey. The results of this workshop, which reveals the troubles, problems and goals of first-year education in Turkey's different architecture schools, create a space for us to evaluate our own studio. In the fourth section, “Starting in the Middle”, we are trying to evaluate our own studio based on the seven categories that emerge from results of "Meeting of First Year Studios of Architecture Schools II" and discuss the limits, opportunities and threats of the proposed methodology. In conclusion, we briefly state the findings and mention the limitations of the study.

2. Architectural Design Education and Studio Pedagogy

In the contemporary research university the architectural design studio is an anomaly. Whereas the positive and applied sciences first theoretically transfer basic knowledge and then apply it in practical situations, fine arts and design departments have a continuous transition between theory and practice (Schön, 1988). The instructor in the design studio acts more like a coach who gives examples, gives advice, questions and criticizes rather than a teacher who conveys knowledge. Most of the time what they do is to control and adjust the duration, speed and repetition of the work according to different individuals. What is practiced or repeated here are the different tools, methods and environments of designing. The student learns by doing together with other students and facilitators. What they learn is not technical knowledge but a particular way of relating to the world. Most of the time, what they learn is unconscious and will be revealed in the future when they need to apply different aspects of design. Schön (1984) proposed to call all these means of communication reflection-in-action. The student reflects the instructor's action and the instructor reflects the student's action. These mutual reflection activities constitute the process of criticism.

First-year design studios are an important part of architectural education. In these studios, design decisions are made at a more abstract level, there are fewer constraints, and the exercises are designed to explore the potentials of design at various scales, from the human to the building and then to the city (Cenani & Aksoy, 2020). The architectural design studio is more than a place to study or listen to lectures. Here the student learns what is nowadays recognised as 'architecture', 'design' and 'the role of the architect' and is introduced to the culture of the architectural profession (Sachs, 1999). They make inferences about what design and architecture is and can be from the behavior of the executives, the terminology they use, the topics they talk about and the political positions they take. According to Aydınlı (2015), studio culture in design education overlaps with constructivist learning theory as it contributes to the learning process with the dialogue environment created by the instructor:

> According to constructivist learning theory, knowledge cannot be directly transferred from an external source to the individual; knowledge is actively constructed by the individual. In this case, the teacher

> contributes to the constructivist learning process not as a teacher in the position of transferring knowledge, but as a coach who prepares environments where the learner/student will discover ways of learning and produce knowledge on their own initiative [...] As a new learning culture, the constructivist paradigm in design education teaches to nurture imagination for a constantly changing world by creating learning environments that enable the development of free and creative thinking. From this point of view, the goal of architectural education should be to create minds with a high capacity to understand the outside world and the individual themself, to train competent architects who can think critically, nurture imagination, have social responsibility and environmental sensitivity (Aydınlı, 2015:1-17).

Fundamentally, constructivist pedagogical models refer to the individual and social learning process, the involvement of mind and body in the process, so that discovery and experience are intertwined. The field of knowledge is not limited and there is no single predetermined way of accessing and transferring knowledge as in positivist scientific approaches (Masatlıoğlu & Takkeci, 2016). In line with constructivist learning theory, Kolb's experiential learning theory sees learning as a cycle that begins with experience, continues with *self-reflection*, and then leads to action that becomes a concrete experience for self-reflection. The experiential learning model has four stages. According to this cyclical process, concrete experience is followed by observation and self-reflection; this leads to the formulation of abstract concepts and generalizations, and then the effects of concepts in new situations are tested through active experiments (Demirbaş & Demirbaş, 2003). According to Kolb (1984), there are two reasons why this model is called "experiential". The first is to explicitly link experience to its intellectual origins in the work of Dewey, Lewin and Piaget. The second reason is to emphasize the central role that experience plays in the learning process. This distinguishes experiential learning theory from rationalist and other cognitive learning theories, which tend to give primary importance to the acquisition, manipulation and recall of abstract symbols, and from behavioral learning theories, which deny any role for consciousness and subjective experience in the learning process.

Freire (2014), to whom Kolb often refers, defines the educational model in which information flows unilaterally and the student is a passive repository as the 'banker' model of education and puts the 'problem-posing' model of education, in which the hierarchy is eliminated through dialogue. The role of problem-posing education is to co-create the environment required for *logos* to replace *doxa* level knowledge by student-teacher and teacher-student. According to Kolb (2015), the essence of the arguments of thinkers such as Paulo Freire and Ivan Illich is that the education system is an instrument of control that maintains an oppressive and capitalist system of class discrimination. The way to change this system is to instill in society what Freire calls "critical consciousness", the active exploration of the personal, experiential meaning of abstract concepts through dialogue between equals. hooks (1994), influenced by Paolo Freire and the Vietnamese Buddhist monk Thich Nhat Hanh, also argues that education should be a practice of freedom. According to hooks, the concept of "engaged pedagogy", which describes progressive and holistic education, is more ambitious than traditional critical or feminist pedagogy because it emphasizes that in order for the teacher to empower students, he or she must also be empowered (or happy). Aykaç (2023) uses autobiographical spatial narrative as a method to enter into this process of mutual awareness and healing that is expected to take place in the studio environment. Accordingly, with a sensitive, tolerant and emotionally aware approach, an oppositional stance can be taken against the collective masculine, oppressive, exploitative and therefore harsh and insensitive mechanisms of existing institutional structures and programmes.

According to Deamer (2020), today's 'typical' architectural design studio is still organized around a model of design mastery from the 19th century, thus failing to meet contemporary needs, and is irresponsible for ignoring pressing issues of spatial justice. The challenge for the studio is therefore its ability to make the connection between design and the rhizomatic world in which it exists. In making this connection, the primary goal should be not to reproduce patriarchal, hierarchical, speciesist, racist and anti-social methods and environments. According to Deamer (2022), pedagogy is performative; it pushes/helps/encourages a certain type of person towards becoming a different type of person: "Currently, standard architectural pedagogy takes an optimistic person who hopes to provide meaningful spaces for society and produces a compliant architectural worker. This conformity is characterized by a striking acquiescence, whether as an employee in a large or small firm who accepts any task, or as a firm owner who succumbs to financial insecurity and social apathy" (Deamer, 2022:189).

In order to act in the intersection of constructivist experiential pedagogy and feminist/postcolonial/radical pedagogy, Spinoza's monistic philosophy that emphasizes affect and intersubjectivity formed our ethical basis for organizing joyful encounters in the studio. According to Spinoza, to act with an active affect is to act by the necessity of the being's own nature, and this contributes to the being's endeavor to exist (*conatus*) and leads to joyful encounters (Balanuye, 2017). Spinoza proposes an ethics of encountering without judgment, an affirmation of joy and the devaluation of moral law. Spinoza's ethics highlights the importance of non-human thought and the agency of bodies (de Freitas et all., 2017). Newness occurs when the body's *conatus* is determined by active affects that transform the world and an education informed by a Spinozist ethics involves both cultivating active affects and rendering the subject imperceptible (Le Grange, 2018). According to O'Donnel (2018) a truly Spinozist understanding of education emphasizes experimentation and diversity. By embracing novel teaching methods, we not only create new ways of thinking and being, but also forge fresh connections and relationships. This approach cultivates a deeper understanding of our place in the natural world, acknowledging our limitations, interdependence, and vulnerability. Therefore a Spinozist approach is in line with our aims of creating a safe learning place for production and critical thinking in the faculty of architecture.

Deleuze and Guattari's anti-capitalist/anti-oedipal approach is also connected to this ethical realm, opening up a rhizomatic space for us to bring different disciplines, tools, subjects and actors together where we can start in the middle. As Deleuze and Guattari (1987:27) suggest "the rhizome has no beginning or end; it is always in the middle". Starting in the middle means starting from the dynamic one, that is, from movement and positioning oneself into becoming. The idea of starting in the middle is based on "entering and exiting, not starting and ending", "displacing the foundation", "nullifying the beginning and the end" in order to create new forms of perception and affect (Yücefer, 2016). It offers an escape strategy to capture what happens in between, to get rid of the stasis of beginnings and endings. Said (2009) argues that "the beginning is ultimately not a simple linear realization, but an activity that fundamentally involves return and repetition". He sees the notion of beginning as "practically part of a whole network of relations" rather than an origin (Said, 2009:17). The idea of starting in the middle destroys the uniqueness of the beginning and replaces it with multiple beginnings. Therefore, the idea that knowledge is only given in a certain place and that one has to start from a certain point to reach it is transformed:

> Every beginning is divided. Just as the authorship of any book is divided, just as an act of thinking always rises on the shoulders of giants, just as an intellect is never inhabited by the individual alone but by many ghosts, everything begins in the furious center of the divided (Raunig, 2019:12).

German biologist Jakob Johann von Uexküll's concept of *Umwelt*, on the other hand, provided a content that excludes speciesism through the disciplines of biology and ethology, where the relations between the human body and other bodies can be scrutinized. In Uexküll's biology, ticks and humans become comparable because what distinguishes one being from another is the quantity, not the quality, of the sensations it possesses. A different habitat (*Umwelt*) with spatial and structural differences creates a different sense of time and place (Uexküll, 2023). The concept of *Umwelt* opens a door to criticize the anthropocene and discuss themes about sustainability and posthumanism.

While we follow the aforementioned learning theories and pedagogies it’s hard to match these theories directly with individual exercises because of the holistic nature of the syllabus. “Starting in the middle” is not just a method or slogan, but also the rhizomatic structure of the syllabus resisting taxonomic categorization and analytical divisions. However, the following table shows a possible match between these theories and our syllabus (Figure 1).

Pedagogical models and educational approaches such as “experiential learning theory,” “reflection-in-action,” “constructivist learning theory,” “engaged pedagogy,” and the “problem-posing model of education” share various affinities with the pedagogical framework of our “Starting in the Middle” studio, explored within the context of architectural design education and studio pedagogy. For instance, the “New Life Forms” work, which involves creating living spaces and forms derived from the formal, functional, kinetic, and systematic analyses of objects found along the campus route, exemplifies “experiential learning theory.” In this theory, observation and self-reflection follow concrete experiences, leading to the formulation of abstract concepts and generalizations, which are then tested through active experimentation in new situations. Similarly, the travel journals, where students initially transform their somatic experiences into text and images, serve as an example of “constructivist learning theory.” This approach fosters a collective discussion environment that encourages self-reflection and the creation of a learning community. The works produced in the “Starting in the Middle” studio, which are analyzed in greater detail in Chapter 4, align well with the pedagogical models mentioned in the theoretical framework. In this context, these models provide a valuable basis for discussing and evaluating the outcomes of the studio.

experiential learning theory	reflection-in-action	constructivist learning theory	engaged pedagogy	'problem-posing' model of education
concrete experience is followed by observation and self-reflection; this leads to the formulation of abstract concepts and generalisations, which are then tested in new situations through active experimentation	The student reflects on the instructor's action and the instructor reflects on the student's action. These mutual reflection activities constitute the process of criticism.	constructivist pedagogical models refer to the individual and social learning process, the involvement of mind and body in the process, so that discovery and experience are intertwined.	It is a practice of freedom. In order for the teacher to empower the students, they need to be empowered themselves.	The role of problem-defining education is to create the necessary environment to replace the doxa level of knowledge by logos, jointly by student-teacher and teacher-student.
• **New Life Forms** After the formal, functional, kinetic and systematic analyses of the objects found on the campus cross-sectional route, the students were asked to design a species whose habitat and form would be determined by themselves from the object in question by using the potentials of the material/form. After careful observation of the objects by drawing, students started to built relations between abstract notions and material properties of the objects. They transferred this new knowledge into 2D and 3D forms in their new organisms. • **Individual final projects** The individual final projects were a test ground for their previous observations and experimentations. All the readings, discussions, material experiments, colloquium critics were tested again in these projects. The 2D and 3D presentation of the projects were evaluated collectively and four of them were selected by voting to be constructed in 1:1 scale.	• **Gazhane "ugly structure"** This assignment arose spontaneously from a student's emotional/aesthetic reaction to a structure in Gazhane. We have realized that students lack critical gaze in order to make aesthetic evaluations. This assignment gave us the opportunity to discuss abstract notions like "ugly", "beautiful" or "functional". • **Burgazada photo competition** Before the evaluation of the photos, there was no introduction to the art of photography. As instructors we haven't defined "the good photograph" but together we discussed the relation between an object and the digital/analogue image of it. We discussed the relation between a mental concept and an optic visual. Our reflections developed during these conversations. • **Burgazada story analysis** This exercise was not successful because the students were not able to reflect in action. First submission was produced individually at home after an ambiguous brief and critics in the studio were not 'clear' enough. It needs to be restructured.	• **Travel diaries** Travel diaries are the first place where students are obliged to transform their somatic experiences into text and image. They start to invent techniques in order to represent a complex reality. Collective discussions support self-reflection and creates a learning environment/community. • **Paper recycling and sewed structures** This exercise brings bodily experience and cognitive/material experimentation together while discussing the concepts of sustainability and structure. The task of designing self-supporting structures using self-made recycled papers was limited with the technique of 'sewing'. This multilayered experience helps students to investigate the potentials of the materials and the interaction with their environment (gravity, pressure, light, etc.).	• **Collective final projects** The final projects were conducted primarily in external locations and extended beyond the conventional temporal and spatial boundaries of the studio. This approach facilitated a more flexible and dynamic engagement with the physical and emotional parameters of the class. Students communicated to other people and students during construction. As instructors we were less visible and students were more in charge and autonomous. We were happy to see the enthusiasm and ambition of the students, as well as the friendships developing in the groups. • **Padlet comments and posts** Padlet platform was expected to be a place for peer communication and sharing experience. However most of the students have not commented to others works and just a few students posted interesting stuff.	• **Notebook production and DIY guide** While exemplary videos were shown beforehand, it is highlighted that the important thing is not the 'final product' but the 'process' which is experienced. The aim of designing a DIY guide was also to increase self-awareness and self-reflection. Some of the defined problems were "sustainability", "upcycling" and "functionality". The upcycled notebooks supposed to become places of self-reflection again while being used during the travels. • **Campus waste map & upcycle inventory** Waste map and inventory projects were also designed in order to problematize the university campus as an ecosystem and to visualize the "waste" not as "garbage" but as a part of the circular economy. This flat ontology breaks in this way the economical and functional hierarchy of objects. • **Sketch workshop: connection elements** The sketch workshop was a good laboratory for students in order to experiment with 1:1 scale objects and to investigate different potentials of materials. They also experimented with different presentation techniques in order to visualize them in 2D.

Figure 1: *Relation between learning theories and “Starting in the Middle” studio practices*

3. "We Have a Problem" and Mapping of Mappings

Despite the existence of numerous conference presentations and academic papers analyzing and discussing individual first-year architectural design studios in Turkey, it remains challenging to obtain a comprehensive overview of this specific habitus of architectural design education. In 2017, Aslıhan Şenel and Nizam Onur Sönmez (ITU) published the outputs of the workshop "Architecture Schools First Year Studio Meeting-II", which was held at Studio-X on 26 June 2015. This was a continuation of the "Architecture Schools First Year Studio Meeting", which was held at ITU Faculty of Architecture in 2014. The workshop, which was attended by 31 facilitators and 10 students, shared the experiences of the first-year studios of Istanbul Technical University (ITU), Mardin Artuklu University, Bolu Abant İzzet Baysal University (BAİBÜ), Fatih Sultan Mehmet Foundation University (FSMVÜ), Yıldız Technical University (YTÜ), Kadir Has University, Eastern Mediterranean University (DAÜ), Maltepe University, Istanbul Bilgi University, Uludağ University, Bahçeşehir University (BAU) and İstanbul Yeni Yüzyıl University. The outcomes of this workshop are valuable for the insight they offer into the state of architectural design education in 2015. The inclusion of students from both state and private universities in different cities allows us to gain a holistic picture of the first-year experiences of architectural design students. Consequently, we will be able to utilize categories and concepts derived from a collective and local field of experience and knowledge. Furthermore, we will have the opportunity to assess the impact of economic, technological, sociological and political changes on architectural education on a global scale over the past decade.

Starting with "declarations of distress", the workshop reveals the problems and possible solutions encountered in the first-year studio with six different mappings created by the participants and ends with a manifesto (Figure 2). Issues such as "production with constraints", "the relationship between critical thinking and creative production", "experimentation and studio as a research area", "personal differences and multiple productions", "the relationship between architectural design studio and other courses", "the relationship between architectural production and representation", "educational outputs and architect identity", "transparent, participatory and egalitarian education", which were put forward before the workshop, remain valid after about ten years. The concept that comes to the forefront in the issues put forward in the maps is "motivation". Accordingly, motivation can increase with the sense of trust between the instructor and the student, with the physical environment of the studio being under the control of the student, with the practices of making together, and with the instructor opening space for different forms of production for the student. On the other hand, unlimited possibilities (undefined task), inadequate timing, excessive hierarchy or one-way transmission can decrease motivation. The common desire that emerges from the thirty-

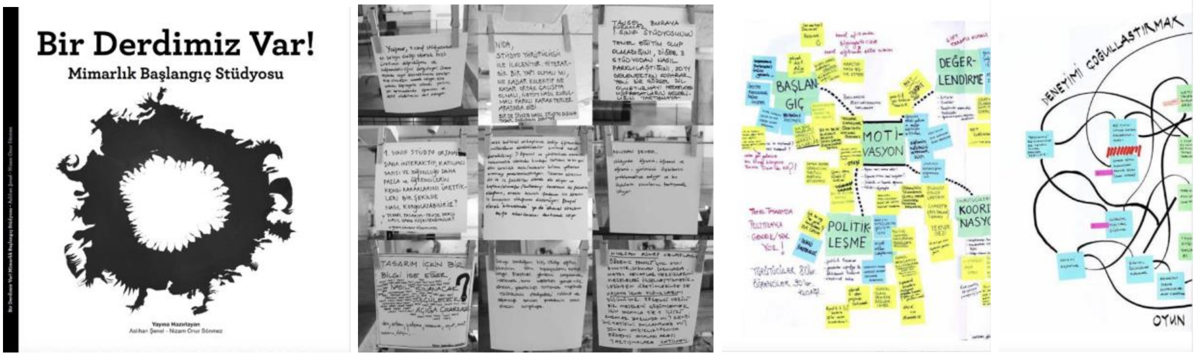

Figure 2: *"Declarations of distress" and "one of the six mappings" (Meeting of First Year Studios of Schools of Architecture-II)*

nine-point manifesto can be summarized as the creation of a free and open learning environment. Another important point emphasized here is that the first-year studio is not the 'foundation' of a specific curriculum or professional formation, but a 'starting' situation that can evolve in different directions (Şenel & Sönmez, 2017).

We analyzed six mappings generated during the discussions on studio-related issues at different tables in the "Meeting of First Year Studios of Schools of Architecture-II" workshop. These mappings sometimes converge on common themes and sometimes diverge in their focus. Various topics emerge, including the content and structure of the studio, methods employed, representation tools, the studio environment, student motivation, and evaluation practices. When we analyze the mappings according to the prominent concepts, it is possible to identify seven categories: content, method, representation, context, motivation, hierarchy and evaluation. However, since these categories are not strictly separated from each other, it is often possible to write the actions under them in more than one category. For example, "involving the student in the process of constructing the task" was included under the category of "hierarchy" because it disrupts the

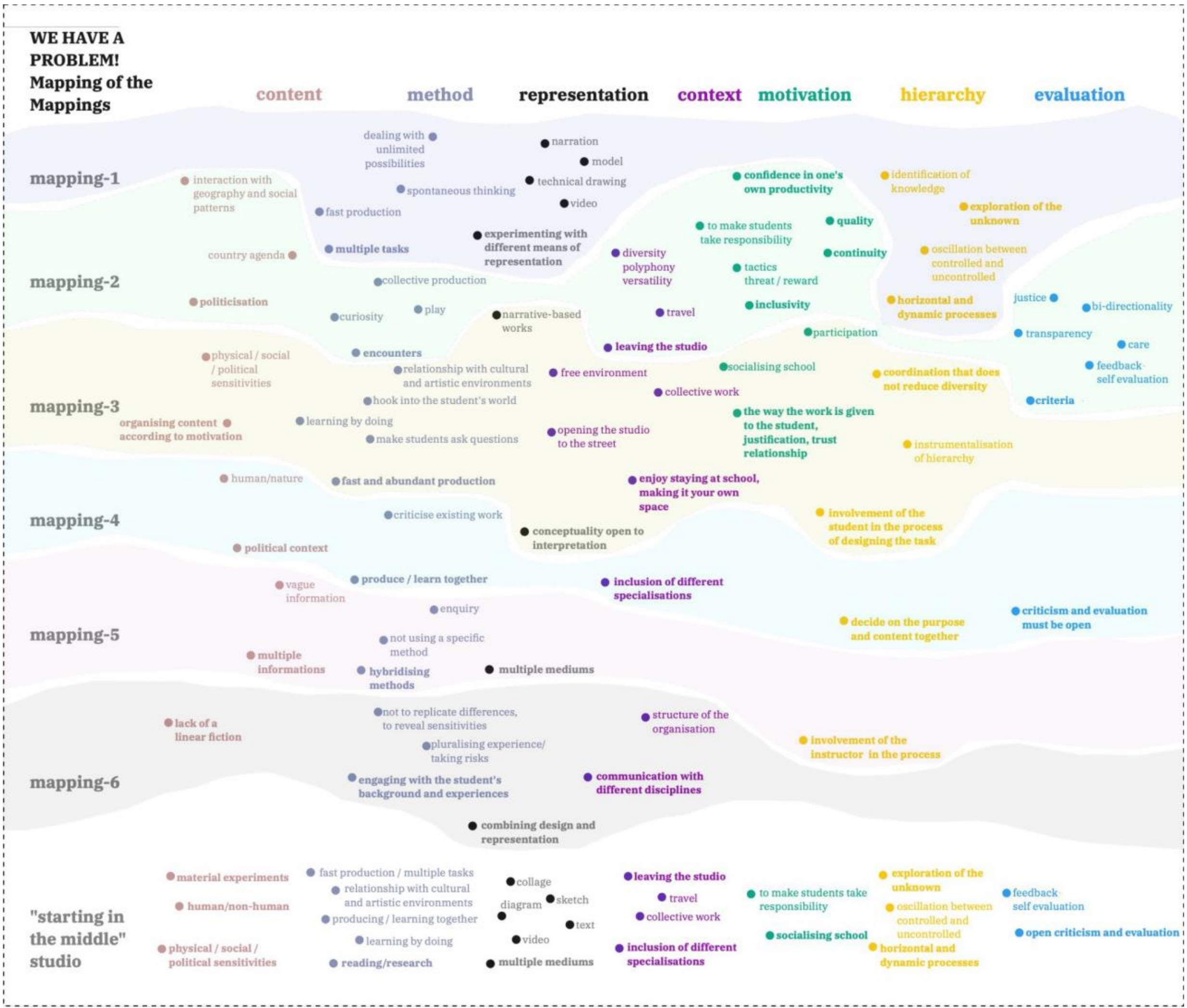

Figure 3: *Mapping of the workshop outputs of the "Meeting of First Year Studios of Schools of Architecture-II".*

hierarchy in the bank-type education system mentioned by Freire, but it is possible to put it under the category of "motivation" because the student is motivated by gaining self-confidence in this way, and under the category of "method" because the executors use it as a method to increase motivation and question established hierarchies by going beyond the syllabus. Therefore, reading these headings as a rhizomatic network rather than as disconnected areas would be a closer representation to reality, although it would make the analysis more difficult. The diagram in Figure 3 consolidates the suggestions from the six mappings produced during the “Meeting of First Year Studios of Schools of Architecture-II” workshop and attempts a comprehensive analysis. Nearly every mapping contributes insights across the seven categories we established. After the distribution of the six mappings according to the seven categories, we tried to briefly evaluate our own studio according to these categories.

In this context, the “Starting in the Middle” studio seeks to contribute to these seven categories through its scope, way of acting, and methodology. Upon analyzing the works produced in the studio, we believe it has made contributions in the following ways: in the “content” category, through material experiments, explorations of the human/non-human interface, and its approach to physical, social, and political sensitivities; in the “method” category, through rapid production, multiple projects, engagement with cultural and artistic environments, collaborative production/learning, and its emphasis on learning by doing, reading, and research; in the “representation” category, through the use of diverse media, including collage, sketch, video, diagram, and text; in the “context” category, through projects that extend beyond the studio, field trips, and collective work; in the “motivation” category, through its emphasis on responsibility and socializing the studio; in the “hierarchy” category, through its balanced application of both horizontal and vertical hierarchies, with a controlled and uncontrolled oscillation towards the discovery of the unknown; and finally in the “evaluation” category, through its promotion of self-evaluation and the creation of an open, critical environment. In the fourth chapter, we provide a detailed discussion of the works produced in the studio, organized according to these seven categories.

4. “Starting in the Middle”

The syllabus developed for the 2023-2024 fall semester architectural design studio, “Starting in the Middle,” aimed to teach first-year architecture students critical thinking and developing new ways of relating to the world. The goal was to create a production environment that explores architecture’s potential to establish connections between the human and non-human worlds while remaining conscious of the economic, technological, sociological, and political changes in their surroundings. To ensure this production environment was critical, creative, and innovative, we adopted “starting in the middle” as the studio’s guiding method. This approach encourages the pursuit of the unknown, facilitates new encounters, challenges assumptions, avoids definitive conclusions, and follows an experiential path. The concept of “starting in the middle,” with its philosophical underpinnings, provided a tool to challenge conventional beginnings, endings, and accepted norms. Consequently, the structure of the studio was not completely pre-determined or finalized in a single instance. The studio syllabus, first created for the 2023-2024 autumn term, has been updated a total of eight times by the tenth week of classes, with no major changes to the main structure (Figure 4). In this section, we will try to describe the operation of the studio and briefly state which work was done and how the learning outcomes were transferred to other works. We will not mention the Basic Design Studio, which we ran with the same team during the same period and which often 'mixed' with the Architectural Design Studio. Although we experienced a complex process in which the two studios supported each other and sometimes stole motivation and time from each other, it does not seem possible to address the impact of the Basic Design Studio within the confines of this article.

As mentioned before, the seven categories are the fundamental dimensions of a design studio and they are connected to each other in a rhizomatic relationship. Therefore Conrad Weddington's "epigenetic landscape" would be a good model to explain how students wander around the studio topography and start to become designer subjects. Conrad Hal Waddington, a pioneering developmental biologist, introduced the term "epigenetics" in 1942 to describe the complex interactions of genes and their expression during embryonic development. His concept of the epigenetic landscape visually represented the multitude of developmental pathways available to a cell as it differentiates. This metaphorical landscape, with its peaks and valleys guiding the cell's journey, illustrated how environmental factors and genetic predispositions converge to shape development (Baedke, 2013). The design studio is visualized in a similar manner as a landscape consisting of different layers of Content and Representation (e.g. scale, space, volume, material, texture, function, sustainability, image) which start to be formed in pre-university times and continue to be formed after graduation. The Content and Representation layers are surrounded by Context, Evaluation,

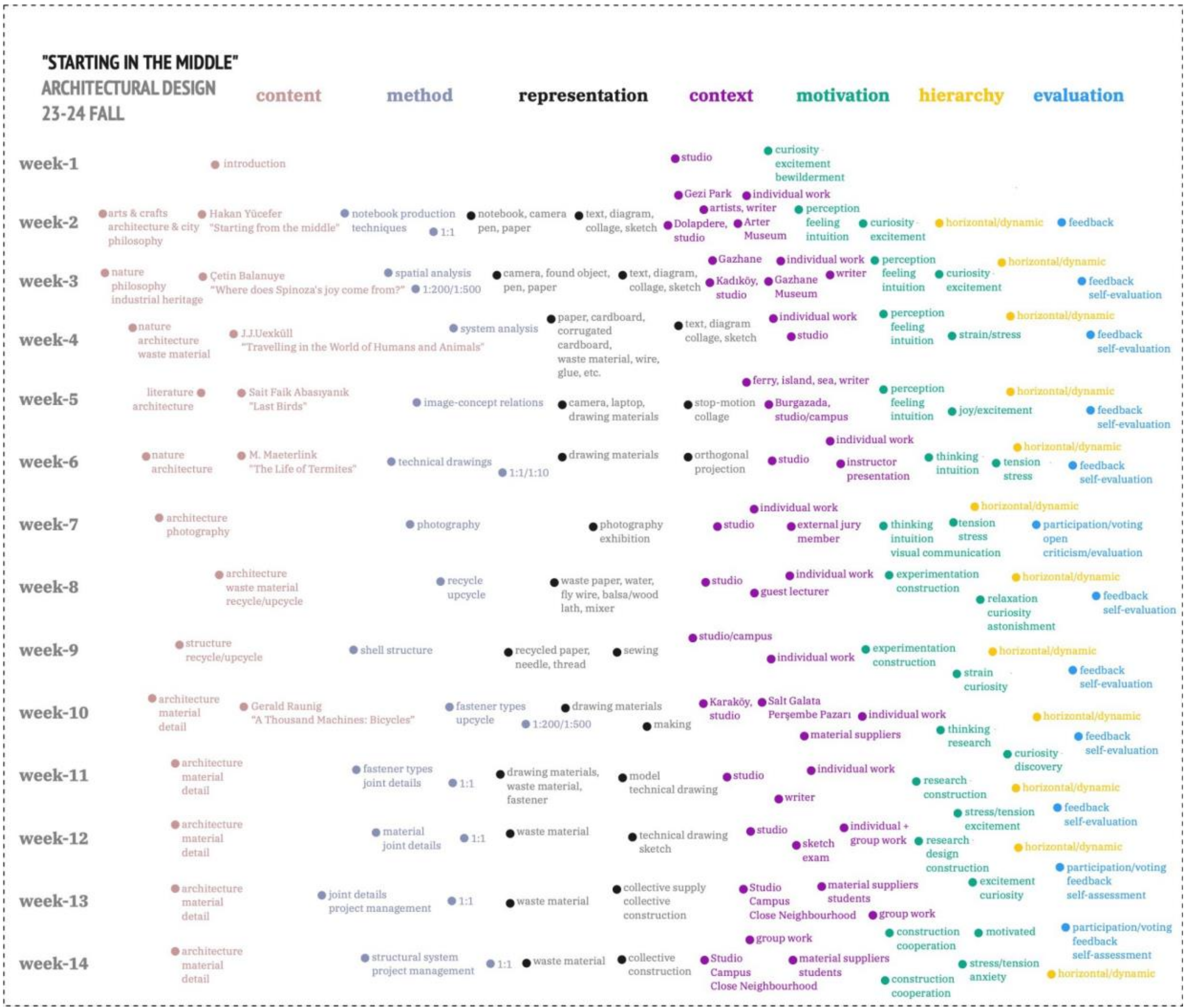

Figure 4: *"Starting in the Middle" 2023-24 Fall Term Studio Syllabus in relation to the seven categories established in Figure 3*

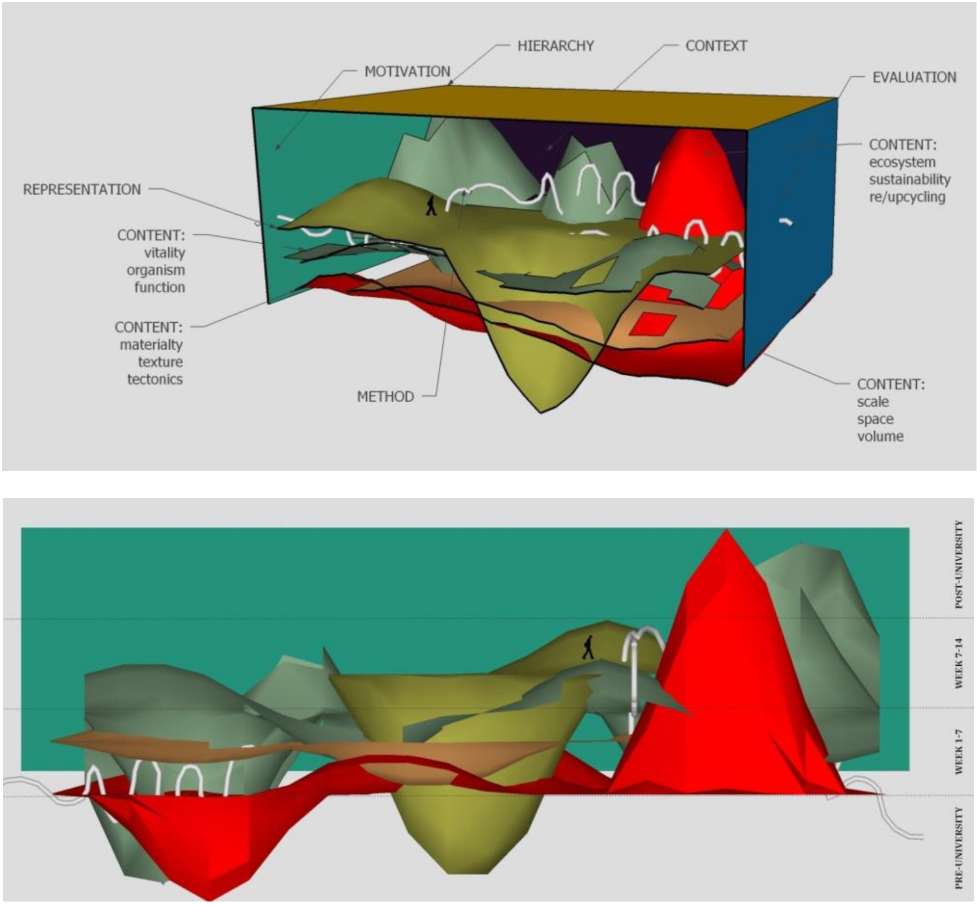

Figure 5: *The Studio Topography or the Pedagogical Landscape*

Hierarchy and Motivation which provide the necessary environmental conditions. The tutors provide connections between different layers and orient the student on different plateaus through the Method (Figure 5).

According to this model the layers of the topography (the Content and the Representation) are existing to some extent and are already in a process of transformation when the students enter the studio environment. These knowledge and skills related to the content and representation are hard or soft, solid or porous and they are in a constant state of change. While tutors keep adding new layers, they do it in a controlled environment which is adjusted via Motivation, Hierarchy, Evaluation and Context. By stitching different layers together, tutors create paths that did not exist before and sometimes they create paths that lead nowhere. Let us explore this landscape starting with the content.

Content:
With the theme of "Umwelt: Building a World", the content of the studio is designed to go beyond the distinctions between culture and nature and between human and non-human, to increase our power of action and to experience joyful encounters in times of crisis (Figure 6). It is possible to say that the content is not disconnected from the national and global agenda and has a political concern, as we are curious about other living beings and different lives on the planet in the age of climate crisis, social turmoil and wars, and we are searching for ways to live together. We think that attempting to build a world should involve relational networks between beings, various temporalities and multidirectional entanglements between human and non-human

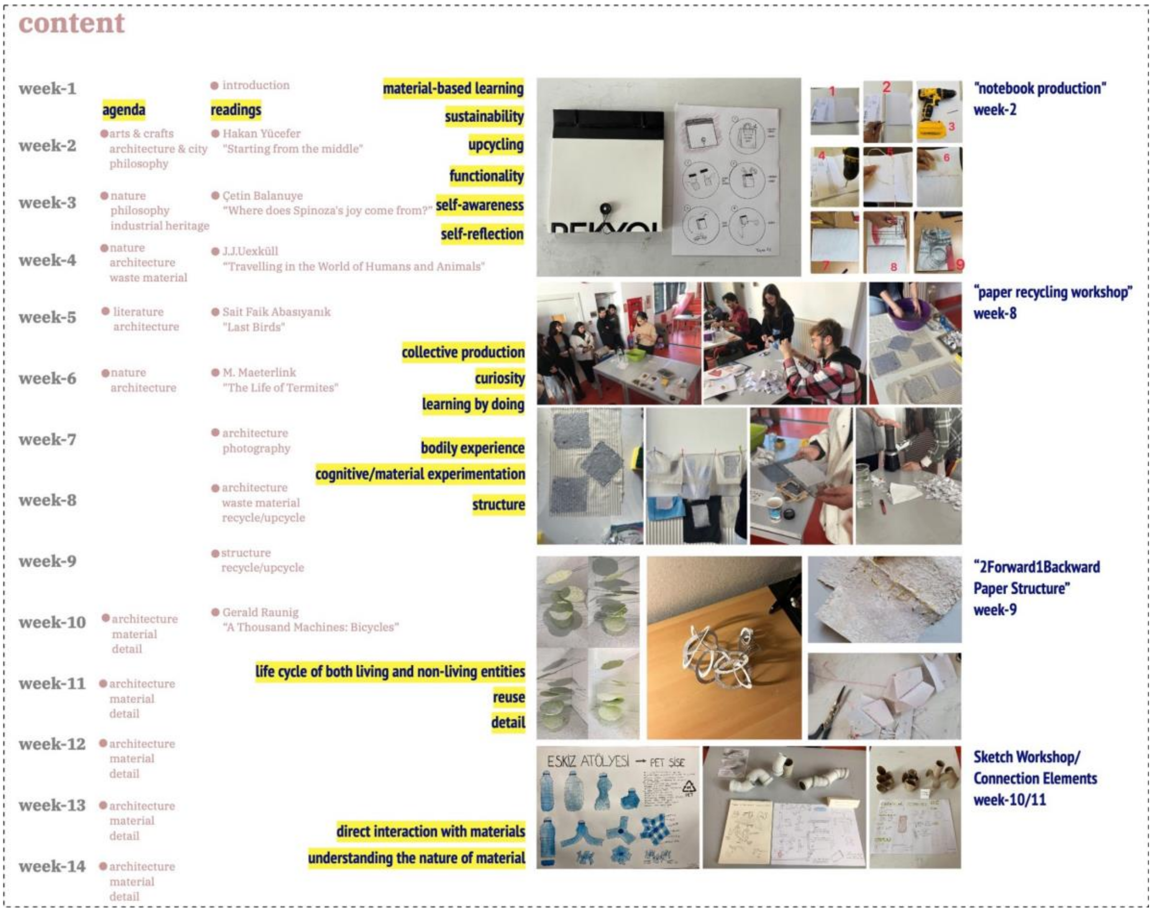

Figure 6: *"Content" outputs of "Starting in the Middle" studio.*

beings. We find it valuable to discuss change and transformation through the relationality of human and non-human factors, to establish and reveal these implicit connections. For this reason, we tried to examine the human-nature relationship around concepts such as sustainability, recycling/upcycling and *Umwelt* through excursions, readings and workshops. A linear structure was not created. A large number of small-scale (excursion notebooks, blind contour, photography competition, story analysis, campus cross-sectional route, campus waste map, Perşembe Pazarı inventory) and medium-scale (upcycling notebook, 2Forward1Backward paper structure, sketching workshop) and two large-scale works were designed (NLF [New Life Forms] and final project). The relationships between the works were left implicit, but space was created for indirect connections to be made through readings, excursions and workshops.

Although it is not prominent on the maps, we tried to create content in our studio to work with waste material directly and at a scale of 1:1. The material-based learning started in the first week with “notebook production” and continued with “paper upcycling,” “sketch workshop,” and final projects. Before the notebook task, exemplary videos were shown, and it was highlighted that the important thing is not the ‘final product’ but the ‘process’ experienced. The aim of designing a DIY guide was also to increase self-awareness and self-reflection while working on materials. The upcycled notebooks are supposed to become places of self-reflection again while being used during travels. To replace the doxa level of knowledge with logos, “sustainability,” “upcycling,” and “functionality” were defined as design problems (Figure 7). The “paper recycling workshop” and the following “2Forward1Backward Paper Structure” task involved direct interaction with materials, bringing bodily experience and cognitive/material experimentation together while discussing the concepts of sustainability and structure. The task of designing self-supporting structures using self-made recycled papers was limited to the technique of ‘sewing’. This multilayered experience helped students investigate the potentials of the materials and their interaction with the environment (gravity, pressure, light, etc.). The workshop was a group effort involving collective production, curiosity, play, and learning by doing (Figures 8 and 9). The sketch workshop in week eleven was a good laboratory for the students to experiment with waste materials and connection elements on a 1:1 scale to explore different possibilities of materials. Students also experimented with different presentation techniques to visualize them in 2D (Figure 10).

As Riskiyanto (2023) points out, material is rarely the first place as the basis of a design approach, but material-based learning in architectural education and practice is important for exploring material thinking in architecture. Learning about the behavior of materials through experience, exploring the dynamics of how different materials come together, and gaining insight into the economic and ecological costs of materials are elements that develop design awareness. In order to perceive the emergence of the built environment, we think it is very important to understand how materials are extracted, transported and assembled. Edensor (2020:13) states that material analyses are "very useful in highlighting radical global inequalities in the distribution of material resources, as well as foregrounding the dominant power of those who can regulate material flows and thus shape the built environment". In this regard, we believe that understanding the nature of material and placing material in an important position in design education can be a crucial input to develop a socially and politically critical perspective.

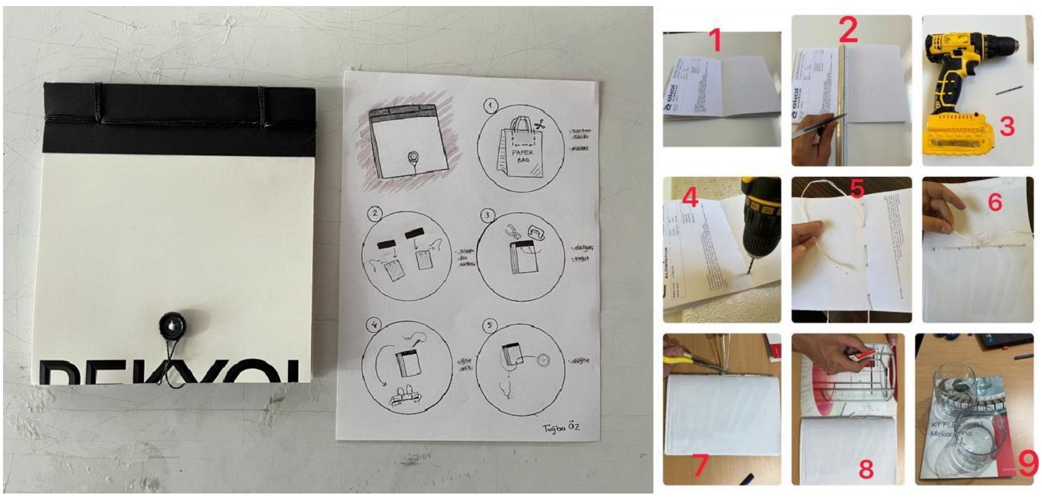

Figure 7: *Notebook Production Guide and Notebook (Tuğba Öz, Emre Saridede)*

Figure 8: *Paper Production Workshop (Executive: Gülşah Aykaç)*

Figure 9: *Structures produced by sewing from recycled waste paper*

Figure 10: *Sketch Workshop/Connection Elements (Yakup Efe Karabulut, Zelal Deniz, Şule Macit, Nisanur Arslan)*

Using waste materials is possible through both recycling and direct reuse. The works shown in Figure 10 formed the basis for our final group project. We began by dividing the campus map into grids, which were evenly distributed among 23 students. Each student was assigned one or two grids and tasked with analyzing the waste within their area to create a comprehensive campus waste map. Viewing the campus as a metabolic system, we considered how the materials identified on the waste map could be reintegrated into the cycle and re-evaluated. Given that our campus includes a diverse range of facilities—such as a cafeteria, stationery shop, forest, and various faculties—the waste produced was equally varied. Starting in the 10th week, we initiated a project to construct a 1:1 structure using these waste materials. The first step involved considering how the waste materials could be combined. This project allowed us to explore the life cycle of both living and nonliving entities and their participation in ecological systems.

Method:
In terms of methodology, there is a great deal of overlap with the "We Have a Problem!" mapping. Methods such as learning to cope with unlimited possibilities, spontaneous thinking, rapid production, multi-tasking, collective production, curiosity, play, learning by doing, questioning, engaging with the students' background and experiences, relationship with cultural and artistic environments were applied throughout the semester. Figure 11 analyzes the studio's outputs in terms of methodology. The studio group conducts research at various scales and employs a range of techniques, including travel diaries, hand-eye coordination practices, system and space analyses, drawing, photography, video, and collage.

The task “Blind Contour” is an example of rapid production, which aimed to bring students physically and emotionally closer to each other in the first week of the semester. Two people sat opposite each other at a table randomly and drew each other's faces without lifting their pencils. We talked collectively about the products, emphasized hand-eye coordination

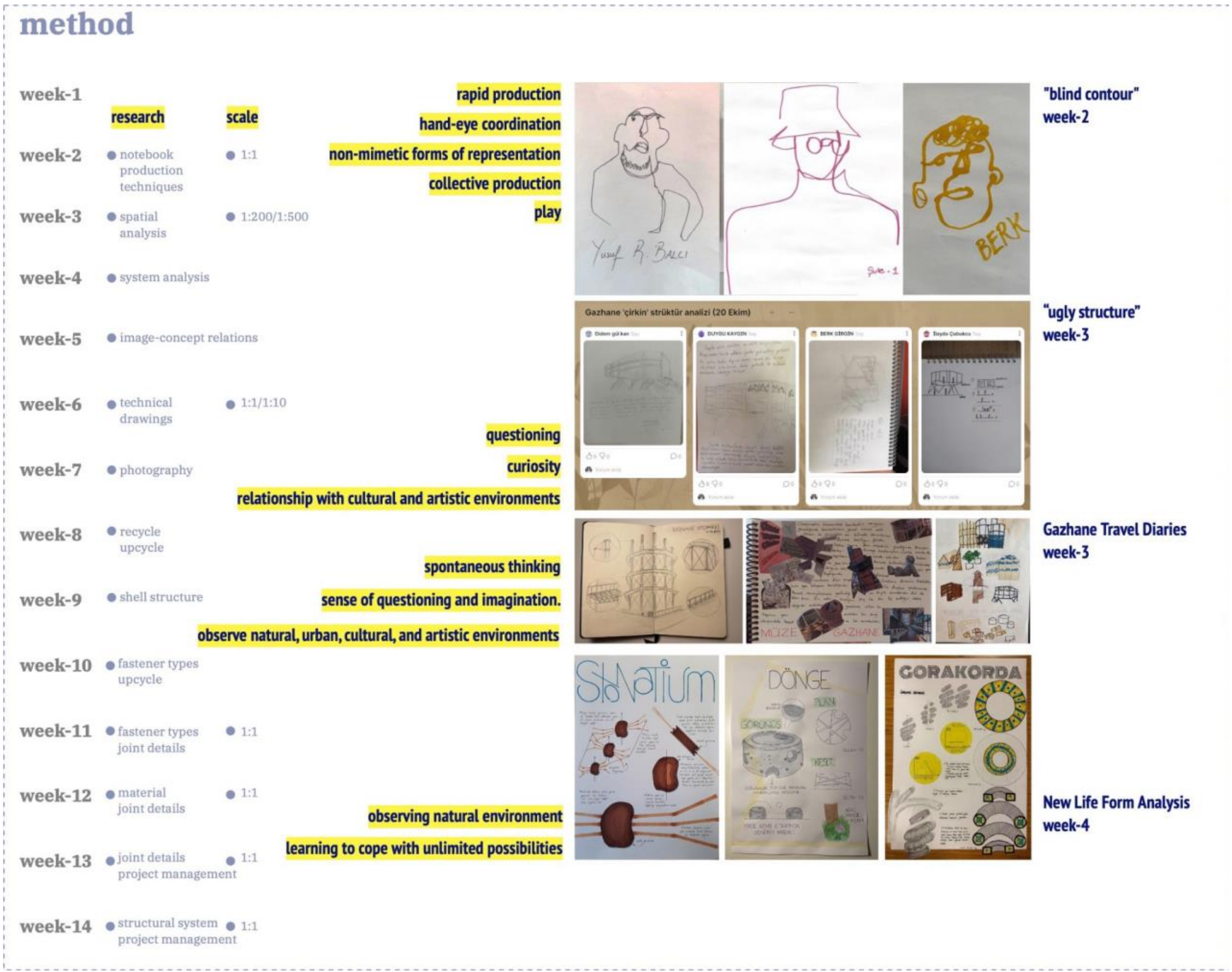

Figure 11: "Method" outputs of "Starting in the Middle" studio.

Figure 12: *Blind Contour (Yusuf by Şule Öztürk, Şule by Sude Hur, Berk by Didem Gül Kan)*

during sketching and talked about non-mimetic forms of representation (Figure 12).

"Ugly Structure" is an example of reflection-in-action where the student reflects on the instructor's action and the instructor reflects on the student's action. This assignment arose spontaneously from a student's emotional/aesthetic reaction to a structure in Gazhane. We realized that students lack a critical gaze to make aesthetic evaluations. This assignment gave us the opportunity to discuss abstract notions like "ugly", "beautiful" or "functional" (Figure 13).

Tasks such as the "Excursion Notebook," "Photography Competition," and "Perşembe Pazarı Inventory" encouraged students to

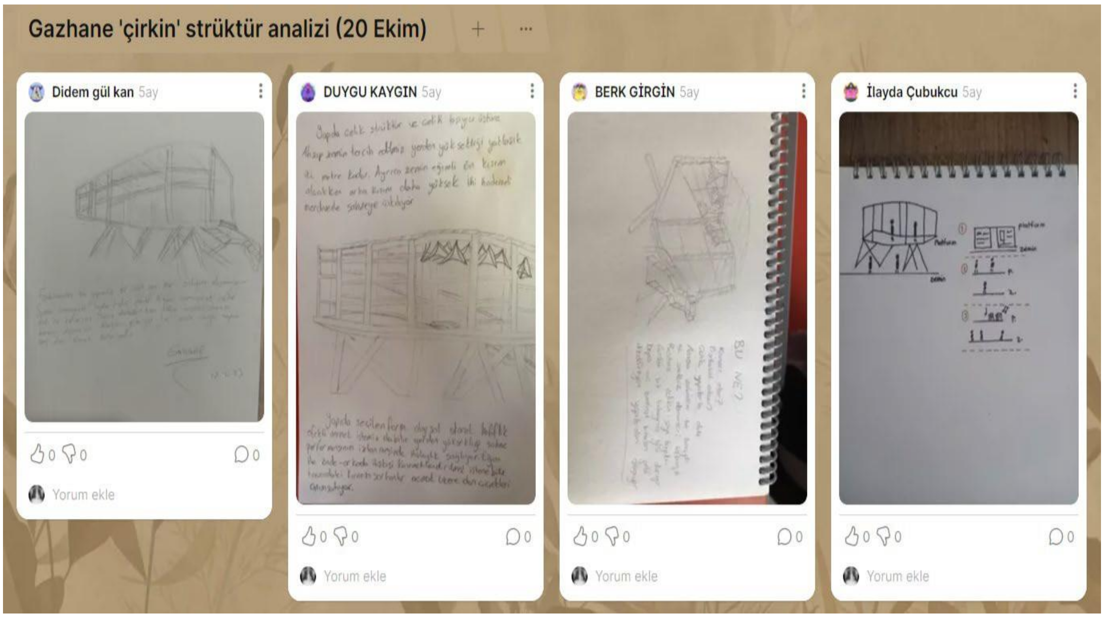

Figure 13. *'Ugly' Structure Analysis (Didem Gül Kan, Duygu Kaygın, Berk Girgin, İlayda Çubukçu)*

Figure 14: *Arter Travel Diaries (Rabia Yılmaz, Nisanur Arslan, Şule Macit)*

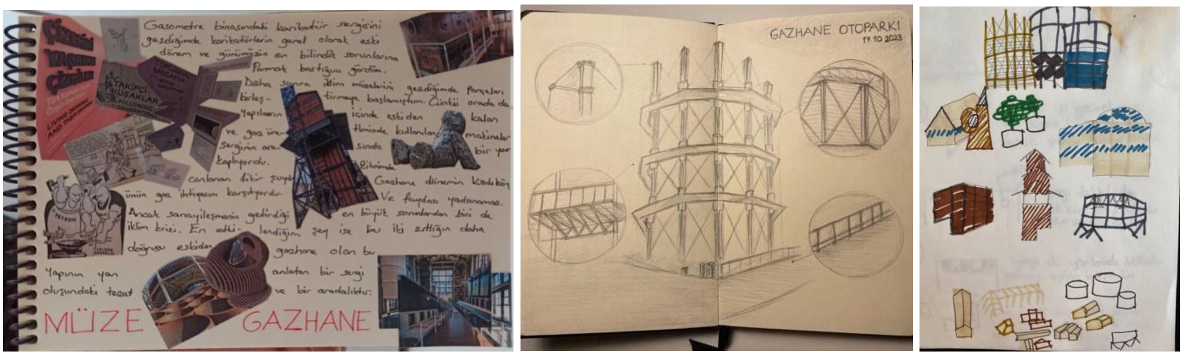

Figure 15: *Gazhane Travel Diaries (Duygu Kaygın, Nisanur Arslan, Yusuf Rabbani Balcı)*

observe natural, urban, cultural, and artistic environments with clarity and curiosity, fostering a sense of questioning and imagination. Following the Arter and Gazhane excursions, students conducted research on the artworks and locations, blending their reflections and impressions with analytical data in their notebooks (Figures 14 and 15). The Perşembe Pazarı trip also helped them shift their perspective from a tourist gaze to focusing on the spatial interactions between people and objects. Similarly, the Burgazada trip and photography competition prompted students to view their surroundings with heightened awareness, merging bodily sensations with conceptual imagery.

In the NLF task, after conducting formal, functional, kinetic, and systematic analyses of objects found along the campus cross-sectional route, students were asked to design a species whose habitat and form they would determine based on the object in question, utilizing the material/form's potentials. Following careful

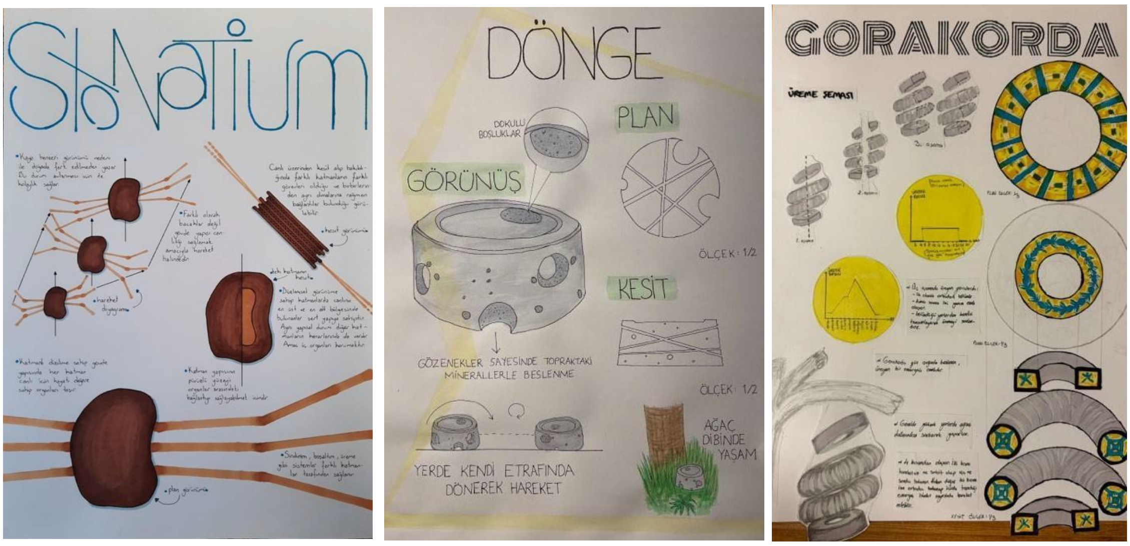

Figure 16: *NLF Posters (Zelal Deniz, Nisanur Arslan, Didem Gül Kan)*

observation and drawing of the objects, students began to establish connections between abstract concepts and the material properties of the objects. They then translated this new knowledge into 2D and 3D forms in their newly designed organisms. This large-scale project allowed students to navigate unlimited possibilities within a limited timeframe while learning by doing (Figure 16).

A student who used materials from his childhood in his notebook production work, students who partially involved their families to supply of materials and tools for the final project, and a student who transferred the knowledge of the department she previously studied to some of her works can be given as examples where students transfer their previous personal experiences and habitus into their projects.

Representation:

The only warning about representation was the need to distance oneself from optical and mimetic representations that allegedly reflect the real world. For this reason, the use of different means of representation in multiple media was encouraged. In the “Starting in the Middle” studio, representation was one of the main focuses. We explored various topics, methods, and research approaches across different spectrums, which naturally led us to use a wide range of representation techniques and media (Figure 17). These included diagramming, narrative, drawing, collage, video, stop-motion, and model-making. In this respect, our approach aligns closely with the representation category that emerged from the mappings produced during the “Meeting of First Year Studios of Schools of Architecture-II.”

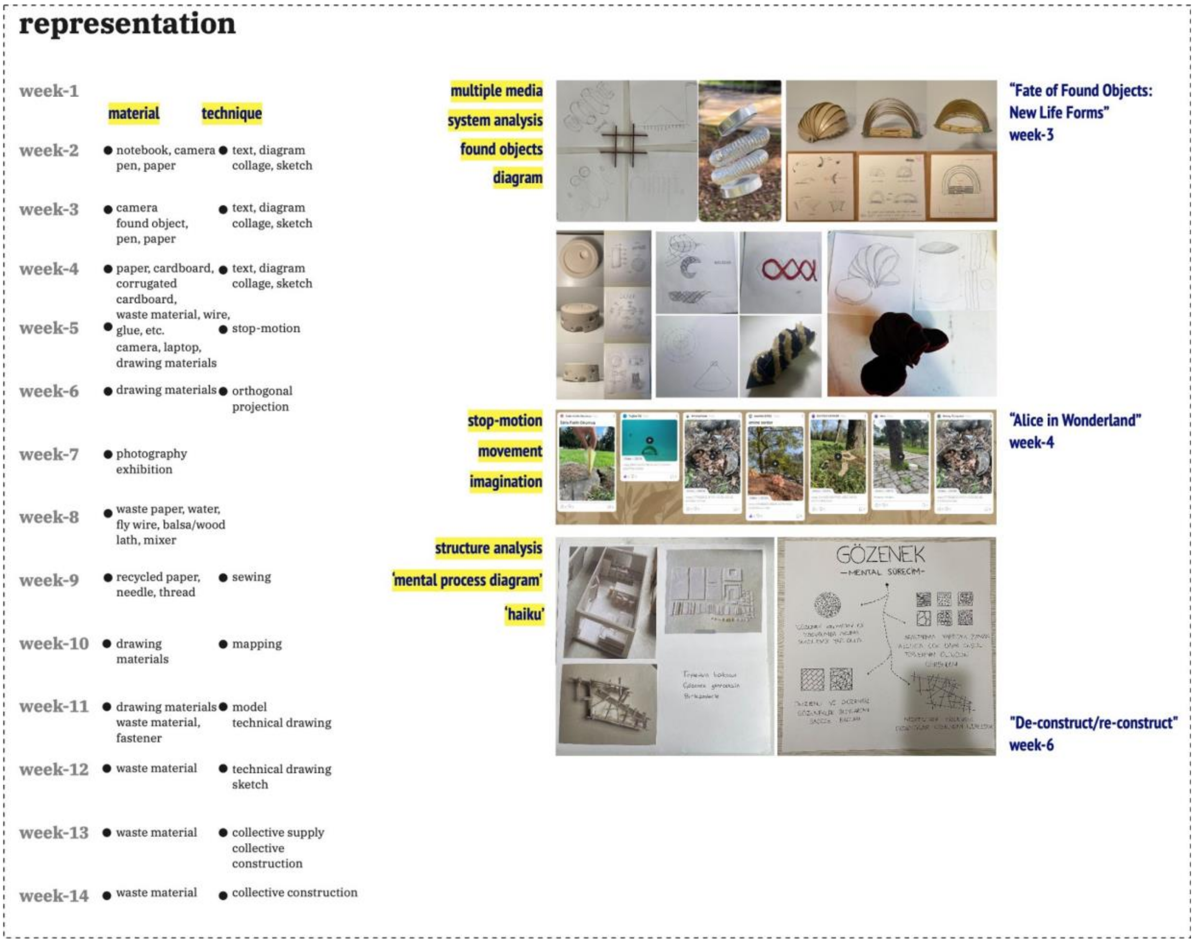

Figure 17: *"Representation" outputs of "Starting in the Middle" studio.*

For example, the work "Fate of Found Objects: New Life Forms" (Figure 18) involved a comprehensive and meticulous analysis of an object, whether living or nonliving, animate or inanimate, discovered along the campus section route. The primary objective was not merely to recreate or represent the object as it was found, but to delve deeply into its intrinsic characteristics and to reimagine its existence through a creative lens. This analysis encompassed a range of the object's attributes, such as its inherent movement, structural form, underlying composition, and latent potential for transformation. The process began with a series of detailed drawings that captured these qualities, which then informed the subsequent construction of a physical model. In the final phase, the object underwent a dynamic re-envisioning, transforming into an imaginative life form. This metamorphosis was captured through a stop-motion video (Figure 19), marking the culmination of the creative journey from observation to animation. Although the stop-motion technique showed improvement after several repetitions, the diagram had not yet been fully internalized at this stage.

Figure 18: Use of 3d model, sketch and diagram in the "Fate of Found Objects: New Life Forms" (Didem Gül Kan, Tuğba Öz, Simay Özayman, Nisanur Arslan, Göksu Bayraktar)

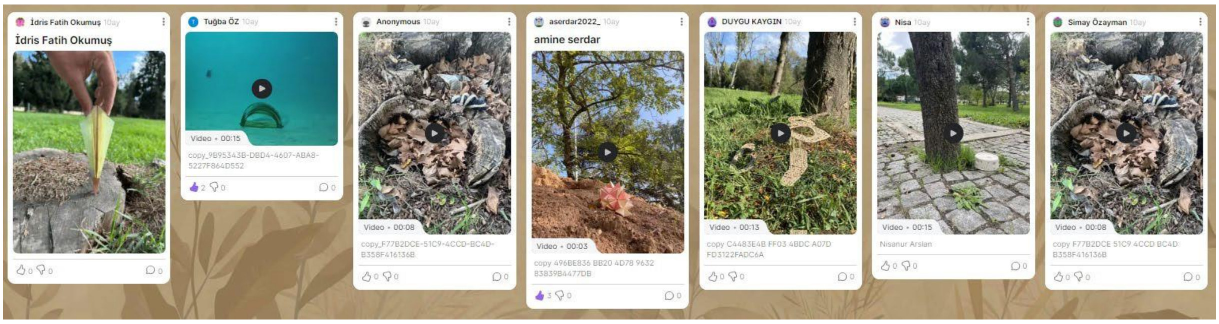

Figure 19: *Use of stop-motion in "Alice in Wonderland" (İdris Fatih Okumuş, Tuğba Öz, Amine Serdar, Duygu Kaygın, Nisanur Arslan, Simay Özayman)*

The technical drawing skills learned in the related compulsory course were successfully transferred to the design studio. We believe that the parallel design of the technical drawing course and the related parts of the project studio contributed to this success. The gray area between technical drawing and non-representational drawings was also explored.

For example, we aimed to produce new and subjective expressions from the physical models of their own rooms, created in the technical drawing course, by dividing them into pieces in the studio and reassembling them according to a specific rule. Additionally, students were required to explain this transformation process with a 'mental process

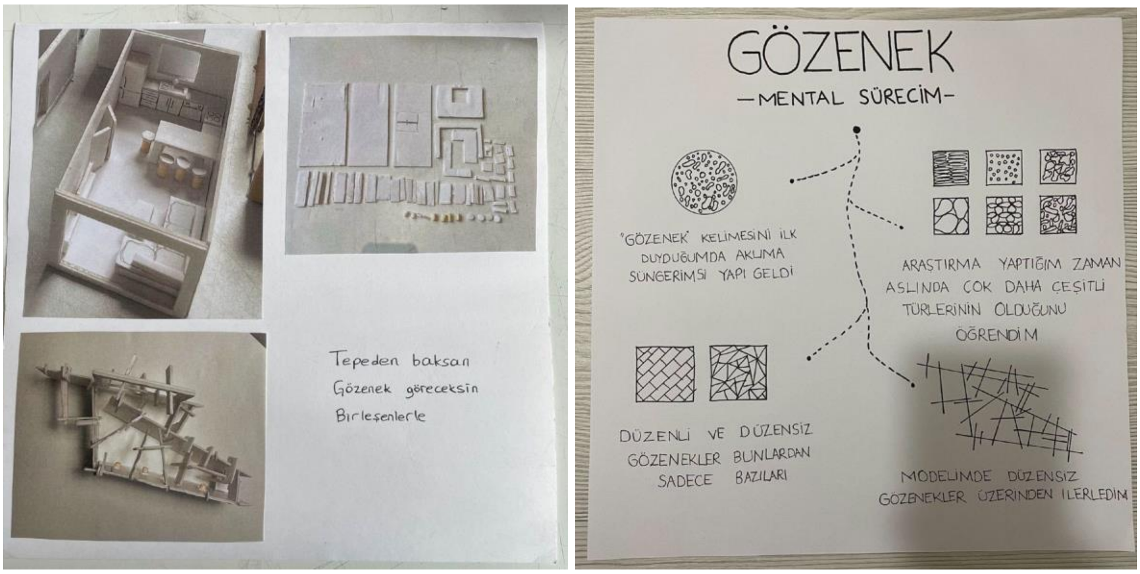

Figure 20: *Use of 3d model, poem (haiku) and diagram in "De-construct/re-construct" (Nisanur Arslan)*

diagram' and a 'haiku' (Figure 20). This approach not only strengthened their understanding of technical representation but also encouraged them to develop a personal and creative language in their designs, bridging the gap between precision and imagination.

We explored how to express our ideas about space beyond technical representation through various representation techniques. As we approached the end of the semester, some students surprised us by creating three-dimensional models using Revit and Rhino, even before taking the related courses. Although we believe that, in many respects, we align closely with the representation debates raised by the "We Have a Problem!" mappings, it may be a shortcoming of the studio that not enough examples of representation were opened to discussion.

Context:
In the "We Have a Problem!" mappings, discussions relevant to the "context" category include various actions such as leaving the studio, exploring external environments, making field trips, engaging with different disciplines, working collaboratively, and embracing pluralism and multi-environmentality. Within this framework, our studio setup demonstrates significant diversity in the context category. We incorporated various urban spaces, including Burgazada, Karaköy, and Kadıköy, into our research and studies. Additionally, our setup featured an open studio in our own building, collective projects, interdisciplinary readings, and presentations, as well as the use of digital platforms such as Teams and Padlet (Figure 21). Furthermore, we engaged with a wide range of actors and environments, both living and nonliving.

One of the factors that significantly affects the course of the studio is the physical environment. If we imagine the physical environment as a circle with the student's desk at the center, we encounter a very deterministic living space that starts with the size, location, and usability of the desk and expands to the size, lightness, and airiness of the classroom, the accessibility and opportunities of the campus, and the accessibility and opportunities of the city. This semester, we were fortunate to have the entrance part of the building with a stepped lecture theater reserved for us, instead of a classroom enclosed by walls on all four sides. This provided us with a flexible and interactive space for various activities such as film viewings, workshops, presentations, exhibitions, and colloquia (Figure 22).

Figure 21: *"Context" outputs of "Starting in the Middle" studio.*

Figure 22: *A flexible and interactive studio for various activities such as film viewings, workshops, presentations, exhibitions, and colloquia*

We also had the opportunity to interact frequently with students and instructors from other studios. Our campus, situated in a forested area, provided a polyphonic environment rich with diverse experiences, enhanced by trips to Arter, Gazhane, and Burgazada. These excursions facilitated closer communication among students and between students and instructors, thereby strengthening interpersonal connections. Additionally, we had the chance to engage with different disciplines indirectly through texts, reading and discussing topics from architecture, art, literature, natural sciences, and social sciences. Collective work fostered the sharing of feelings and experiences. For the final project, students traveled around the city to procure materials and engaged with various individuals. They collaboratively addressed numerous problems and responsibilities related to the project. The "Beaver Nest" team primarily worked outdoors in the forest, while the "Things" team continued their production in the faculty building until late in the evening (Figures 23 and 24).

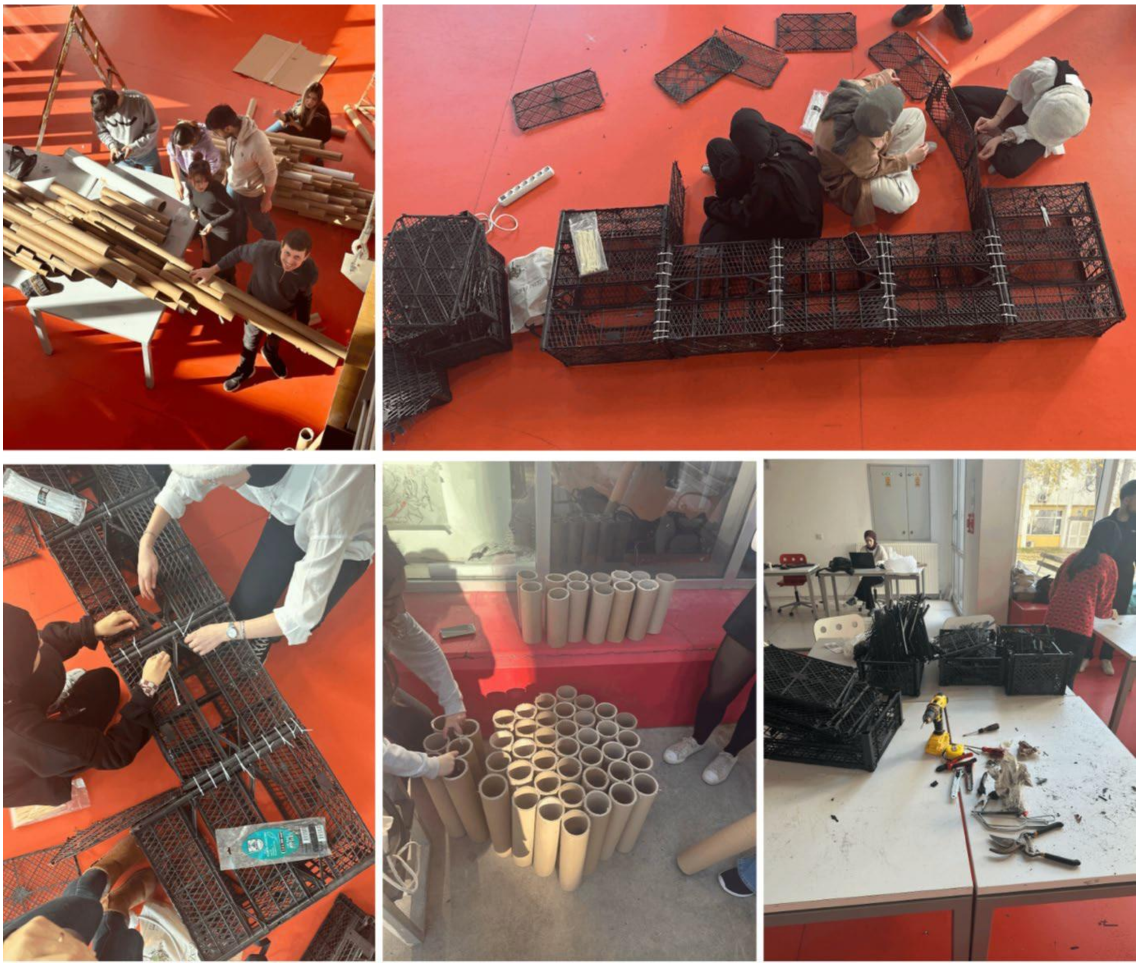

Figure 23: *Studio as a construction site. Production process of the final groups in the studio:* ***Open Stage*** *[Tuğba Öz-Hümeyra Hafif-Şule Macit-Rabia Yılmaz-Emre Saridede-Sude Hur],* ***Bergére*** *[Nisanur Arslan-Simay Özayman-Şeyma Nur Temel-Seray Yurtsever-İlayda Çubukcu-Duygu Kaygın],* ***Beaver's Nest*** *[Nur Yaşa-Şahin Tütüncü-Göksu Zeynep Bayraktar-Zelal Deniz-Berk Girgin],* ***Things*** *[Didem Gül Kan-Yakup Efe Karabulut-Yusuf Balcı-Şule Öztürk-İdris Fatih Okumuş-Amine Serdar]*

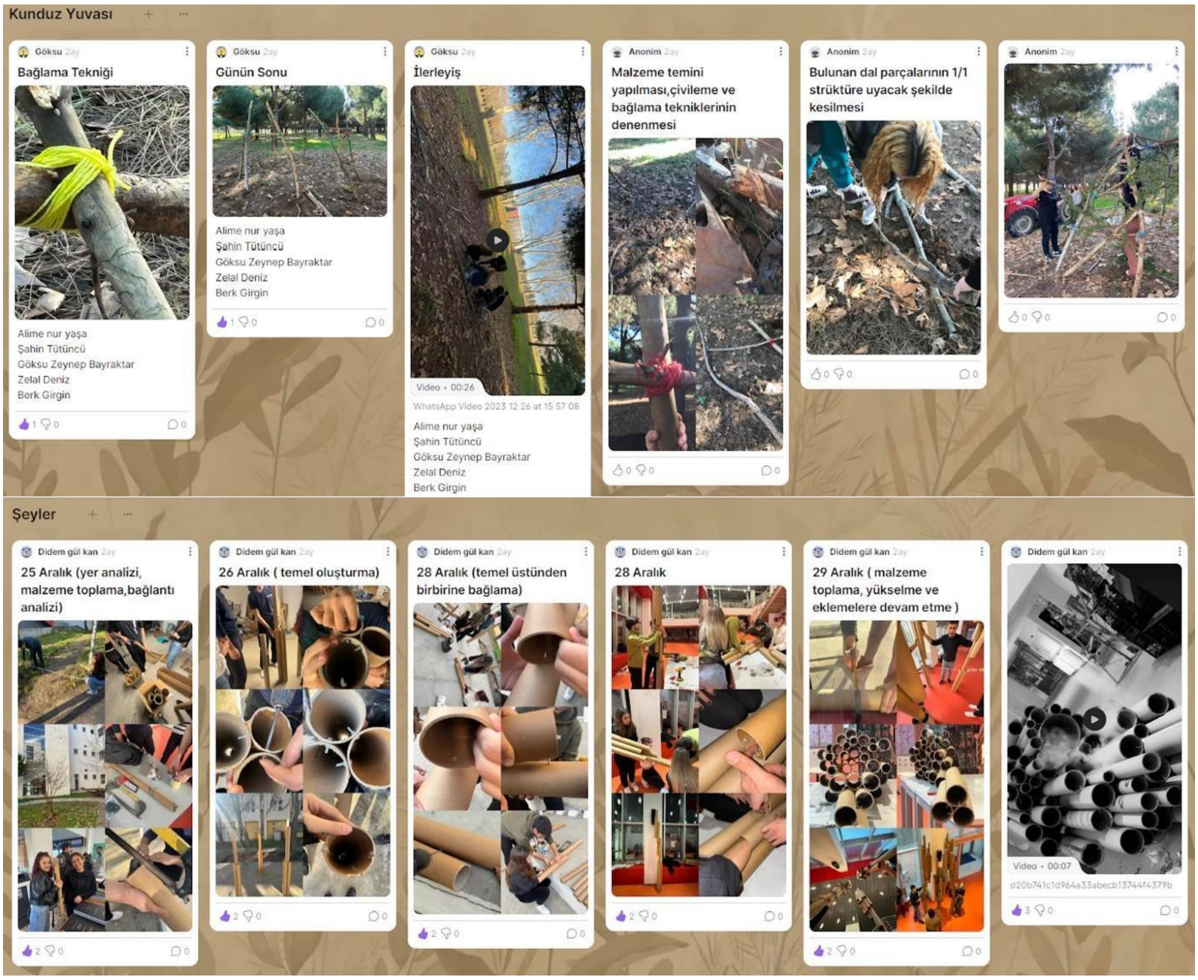

Figure 24: *Work process of the teams "Beaver's Nest" and "Things. The process is uploaded by team members to the Padlet platform.*

Throughout the process, we effectively utilized digital platforms as extensions of our physical spaces, creating an integration between the two. All work, process documentation, and ongoing developments were consistently shared on Teams and Padlet, ensuring that every participant remained informed and engaged. Additionally, these platforms served as hubs for communication and collaboration, where event announcements, essential texts, suggested places to visit, current exhibitions, and other relevant information were shared on a common Padlet page accessible to everyone involved. The integration of these digital tools was crucial in maintaining continuity, fostering collaboration, and enriching the overall learning and creative experience.

Motivation:
It can be said that sufficient motivation was created in the studio without using any concrete threat or reward from the beginning of the semester (Figure 25). After the group introductions at the beginning of the semester, the students were placed in the group of their choice among six different first year studios that differed in terms of fiction and theme. In relation to learning styles, motivation increases in works requiring design, application, physical performance and teamwork, while general motivation decreases in text reading and discussions. Defining the tasks, limiting the time and producing them quickly had a positive effect on the students' taking responsibility. Group work and excursions had a positive effect

on motivation as they provided opportunities for socialization among peers. The fact that the whole school could see the works at the colloquium, the presence of an external lecturer in the jury, the observation of the team work by others due to the fact that the classroom was located in the entrance hall, the visibility of the working area of the "Beaver Nest" team in the forest close to one of the main pedestrian roads in the campus (they appeared on the student instagram page of the school with the structure they made) are seen as factors that increase motivation. Continuously following, photographing and sharing students' work on social media can also be a motivational factor. The fact that students do a job with high motivation and produce a qualified product increases the motivation of the instructors directly and enables them to be better prepared for the next week's task.

Throughout the semester the 'Teams' programme was used for assignment submissions and announcements, and the 'Padlet' platform was used as a common sharing space (Figure 26). Padlet was expected to be a place for peer communication and sharing experience. However most of the students have not commented on others' works and just a few students posted interesting stuff. This may be attributed to the fact that they have already established communication channels on alternative platforms -such as Snapchat, TikTok, Telegram, or Whatsapp- which renders Padlet unnecessary to communicate with each other.

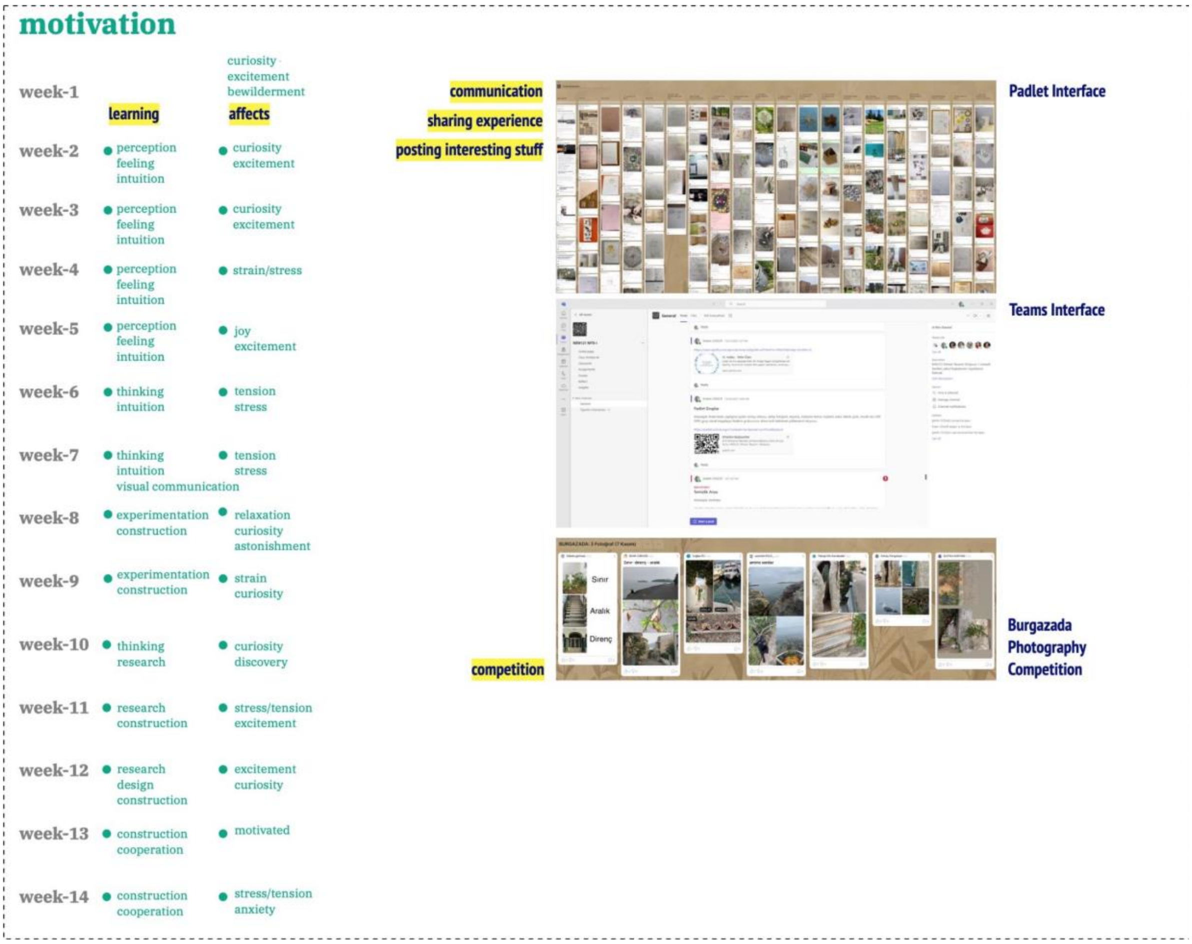

Figure 25: *"Motivation" outputs of "Starting in the Middle" studio.*

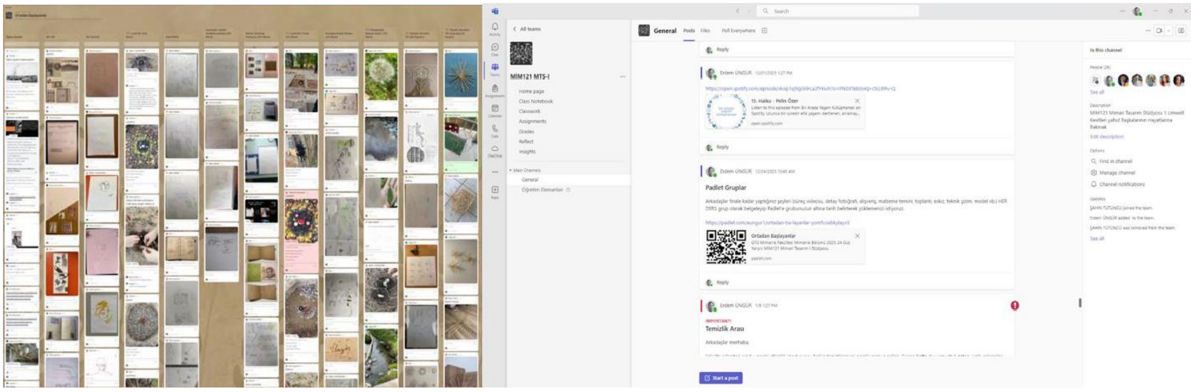

Figure 26: *Padlet Interface (left) and Teams Interface (right)*

The photography competition was designed to increase motivation but because of not having a clear selection criteria and voting mechanism students were not as enthusiastic as expected. Also a problem with the projector forced students to view the photos from their cell phones. However, because of their curiosity and commitment we were able to discuss the relationship between concepts and visual images in the context of Burgazada (Figure 27).

Hierarchy

In order to break the expectation of the "knowing subject" that rightly comes from the student, we tried to point out the dark spots in the epistemology of architecture indirectly. For this, it is enough to bring different perspectives and interpretations into play, but we also tried to oscillate between controlled and uncontrolled areas in order to prevent the student from getting lost in a nihilistic and unlimited world of subjectivity. For instance, we tried to connect the forms of representation with historical and social events by talking about abstraction, collage, reverse perspective and miniature against mimetic/figurative representations. In this respect, we can say that we endeavored to provide guidance indirectly, if not directly, at some points. On the other hand, since we did not impose a template in the poster submissions, we also prevented them from gaining the habit of working in graphically "correct" proportions. However, when we came across a poster with "correct" proportions, we tried to explain why it was "good" in the collective evaluation. We can also claim that we were lucky in breaking the hierarchy, as there were students in the studio who were sociable and critical, and participated in discussions with original comments. This participatory attitude, in which everyone, including us, had equal voting rights, especially when determining the projects to be worked and produced as a group in the final project, was an important step in establishing the horizontal and

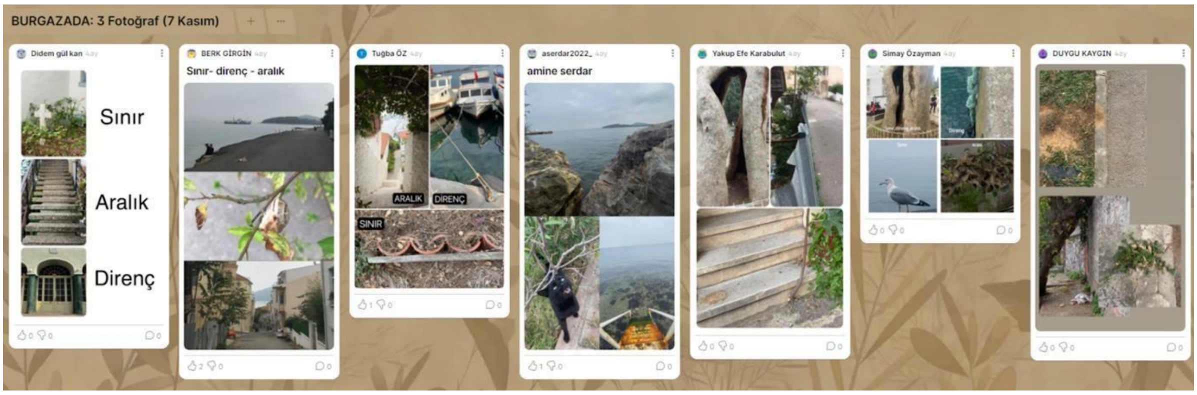

Figure 27: *Burgazada Photography Competition*

dynamic relationship in the studio. Since the first year works usually reveal the root problems in architecture, most of the times we were left unanswered, other "student-teachers" covered our gaps with their answers.

Evaluation:
Although the grading of work is a task that executives hate, students often (probably out of habit from secondary and high school) expect their work to be evaluated numerically. The rational/analytical criteria for numerical evaluation often lead to the invisibility of achievements that cannot be measured quantitatively. During the semester, after the works were delivered, we gathered and collectively evaluated them by thinking out loud. We discussed how we evaluated them, and why we did it this way. We tried to create common criteria for evaluation. Here, we tried to create a suitable atmosphere for students to criticize each other as well as opening a self-evaluation space for students. Therefore, we realized that we were not creating a hierarchical community of minds, but a single common mind together. In addition to collective evaluation, we gave one-to-one feedback to students during production. Since we were two coordinators, we managed to stay on a common ground by giving feedback to each other about our feedback. We encouraged students to make self-evaluation. We announced numerical grades twice in total [colloquium and final grade] during the semester. Since we did not encounter any complaints when we announced the grades, we can conclude that our justifications were accepted. Finally, twice during the semester we held a vote in which everyone had equal voting rights. The voting may have been effective in increasing motivation by making students trust their own decision-making abilities and by introducing play into the studio environment (Figure 28).

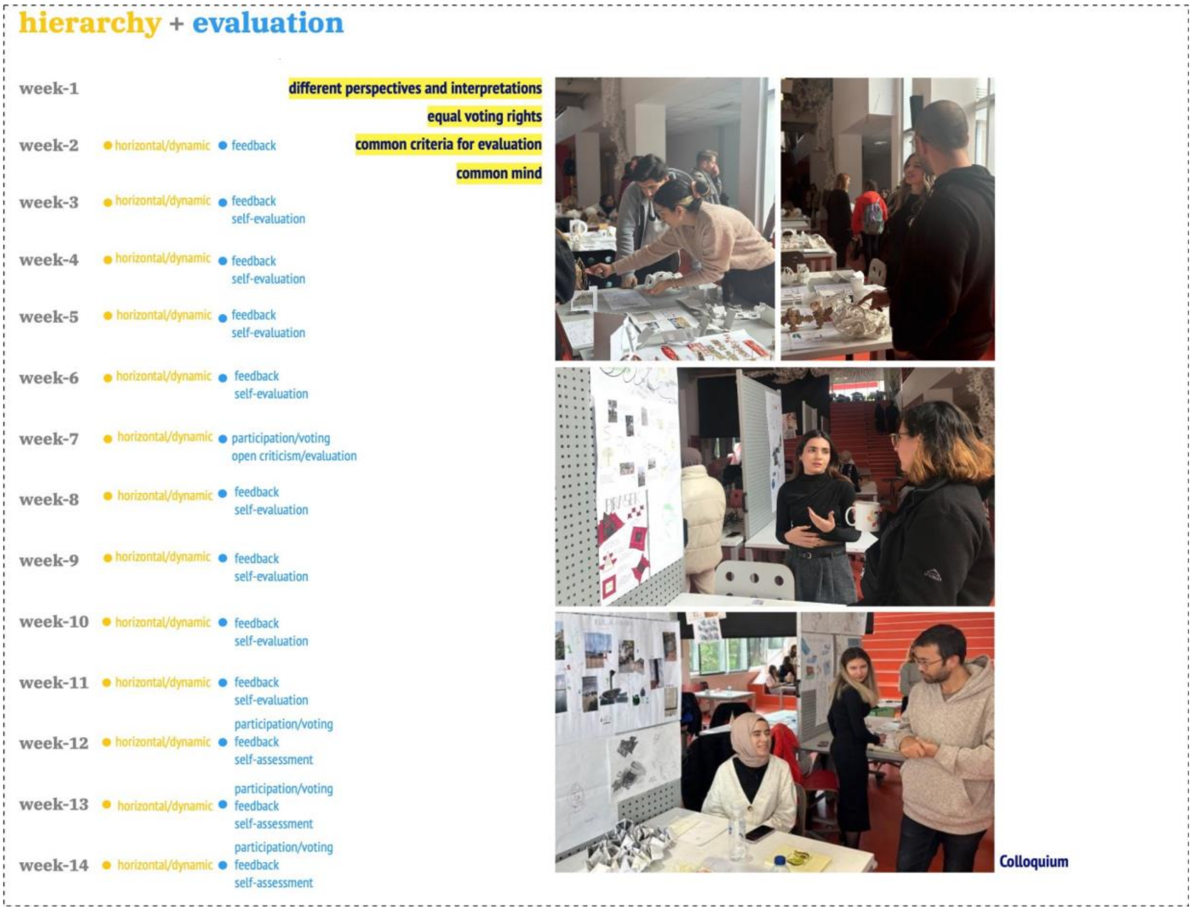

Figure 28: *"Hierarchy" and "Evaluation" outputs of "Starting in the Middle" studio.*

5. Conclusion

In the studio group MIM121 Architectural Design I "Starting in the Middle", which we conducted in the autumn semester of 2023-2024 at Gebze Technical University, Faculty of Architecture, Department of Architecture, we aimed to question how architecture establishes and transforms the relationships between the human and non-human worlds under the theme "Umwelt: Building a World". To this end, we sought to apply a constructivist and experiential studio pedagogy, defining Deleuze and Guattari's rhizomatic idea of "being in the middle/starting in the middle" as the studio's method of working, and Baruch Spinoza's idea of "being the source of virtuous effects" as our way of acting. Around themes such as New Materialism, Actor-Network Theory, Anthropocene, Circular Economy, Sustainability, Fair Design - without directly reflecting the theoretical background - we tried to include discussions and practices that we believe will create responsible and critical designers. Throughout the semester we explored different ways of working with waste materials. We have emphasized that in everything we do we are connected to each other and to the world around us, to other species, micro-organisms, soil, water, and that our primary duty as designers is to protect and maintain the urban metabolism as part of this.

The main limitation of our study is the lack of personal experience of the students. As tutors, we were only able to discuss our personal observations, particularly under the headings of 'motivation' and 'hierarchy' in section four. In future studies this limitation could be overcome through surveys and in-depth interviews with students. Another limitation related to the first one is the difficulty in measuring the level of skills acquired and the difficulty in determining the degree of relationship between different learning outcomes. As the impact of the first year of architectural design education is fundamental and lasting, long-term measurement techniques may be required. Finally, the Basic Design Studio syllabus was directly related to the Architectural Design Studio in terms of learning outcomes, but we couldn't address this relationship within the confines of this article.

Our concerns overlap to a large extent with the 'concerns' raised by the first-year architecture studios of twelve universities in Turkey about ten years ago. During this period, the precariousness of both students and instructors has increased with the rise of crises both in the world and in our country. With the rise of populist authoritarian governments and the Covid-19 pandemic in the world, the attempted coup in Turkey, the unlawful practices of the state of emergency, out-of-control inflation and the housing crisis, earthquakes and other man-made disasters, our expectations and responsibilities for the future have changed significantly. Today, when the need for university education and the existence of many architecture departments are being questioned, we believe that the first year studio is still relevant in the education of critical and creative thinkers. In our current environment, the most important role of the studio should be to create a safe space to breathe. The studio provides us with this experimental space to heal ourselves and others. We hope that the findings of this study will contribute to, or at least inspire, future first year design studio practice, both in terms of content and methodology.

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Ranking of Smart Building Design Factors with Efficient Energy Management Systems and Renewable Resources

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Abstract: This study aims to rank the design factors of smart buildings with efficient energy management systems and renewable resources. The research is applied in nature in terms of its objective, and descriptive-survey-based in terms of data collection. The study population comprised all academic faculty members in the field of architecture. Based on the collected information, approximately 112 architecture faculty members were included, and given the small sample size, a census approach was used, meaning the sample size was equal to the population. After distributing and collecting the questionnaires, 93 were completed and analyzed. A researcher-made questionnaire was employed, consisting of two sections: the first included personal details (age, gender, marital status, education, etc.), and the second was dedicated to ranking the design factors of smart buildings with efficient energy management systems and renewable resources. The questionnaire was structured on a 7-point Likert scale. To ensure the face and content validity of the questions, feedback was obtained from several architecture professors specializing in the field. Additionally, the construct validity of the questionnaire was confirmed through exploratory factor analysis. The results showed that six factors had eigenvalues greater than one and remained in the analysis. The study found that among the design factors examined, the lighting system, fire alarm system, and temperature and humidity sensors emerged as the most influential in enhancing smart building efficiency.

Keywords: Smart buildings, Smart systems, Efficient energy management, Renewable resources

1. Introduction

The concept of a smart building (Figure 1) is one of the most prominent contemporary trends, integrating the ideas of smart mobility, smart economy, smart people, smart governance, smart environment, and smart living (José, 2024) . The construction sector plays a crucial role in adapting to new challenges in all these areas. Buildings and infrastructures must be constructed and operated in accordance with the characteristics of a smart city (Kuzior, 2024). As a result, the term "smart building" has been widely discussed by researchers, industry professionals, society, and representatives at city and higher management levels (Kuzior, 2024). The European Union's policy focuses on developing ISO standards in specific areas of smart cities, funding smart city lighthouse projects, and providing financial incentives for smart buildings and smart city elements. Smart buildings are considered one of the main components of the built environment in a smart city (Wolniak, 2024).

The first definition of a smart building was published in 1989 by the U.S. Intelligent Building Institute, describing a smart building as providing an efficient environment through optimized structures, systems, services, management, and their interrelationships (Lim, 2024). Later, the emphasis was placed on its impact on operational efficiency, the effectiveness of its occupants, and the utilization of information and communication technologies. Smart cities, whose operational efficiency is heavily dependent on buildings (Stamopoulos, 2024), are the most prominent trend in creating a coherent environment for the future. However, there are no specific recommendations on how to utilize new materials and technologies in construction projects in smart cities (Zwick, 2024). Therefore, it is important to explore which features are more critical for adapting future buildings to the digital smart city platform. It is no surprise that there is a need to identify the integration requirements that construction projects must meet to be compatible with the overall context of a smart city (Nyathani, 2023).

The latest challenges in the advanced development of smart buildings and smart cities are related to digitization: aligning buildings with the new city's ecosystem, adapting to the environment, collecting and transmitting information, real-time communication of information, information management, and action control. Significant attention must be given to developing a new approach based on combining two separate fields that describe the core principles of integrating a smart building within a smart city (Adewnmi, 2024). After the Industrial Revolution, urbanization and extensive construction activities increased energy consumption and its detrimental environmental effects (Jebaraj, 2023). The need for sustainability for every community and individual in all sectors is undeniable and essential.

Traditional building technologies lead to high energy consumption and carbon emissions, exacerbating global warming and climate change (Cong, 2024). To mitigate these adverse effects, the construction industry has shifted towards innovative solutions by adopting the concept of green building, aiming to design sustainable and environmentally friendly structures that effectively utilize natural resources (Lacson, 2023). With the expansion of urbanization, the building sector has become the primary consumer of energy, thus increasing its share of total energy consumption. Constructing green buildings is one of the most effective ways to achieve energy savings (Ai, 2024). Green buildings significantly reduce energy consumption and greenhouse gas emissions, which in turn helps mitigate the harmful effects of climate change. Greenhouse gases have a wide-ranging impact on the climate, and their emissions in international trade are rapidly increasing (Adelekan, 2024).

In recent years, sustainable building practices have garnered significant attention in the construction industry, driven by growing concerns about the environmental impacts of traditional design and construction methods. Given that buildings account for nearly 40% of global energy consumption and 30% of annual greenhouse gas emissions (Kolhe, 2023), there is an urgent need to address these issues. Furthermore, as the world's urban population is expected to double by 2050, increasing the sustainability of buildings and infrastructures has never been more critical (Chen, 2024). Amid these challenges, there is deep optimism surrounding the potential of emerging technologies, particularly artificial intelligence, to revolutionize our approach to sustainable building practices. By employing AI at various stages of the building lifecycle, from design and construction to operation and maintenance, there is a unique opportunity to reduce systemic inefficiencies and enact meaningful changes.

One of the most significant issues facing the construction industry is the staggering amount of waste generated during construction (Stecyk, 2023). Globally, 11 to 15% of materials are wasted on construction sites, highlighting the need for more efficient processes and resource use. Additionally, operational inefficiencies significantly contribute to the carbon footprint. For example, lighting, heating, and cooling account for approximately 28% of the energy consumption of commercial buildings in the United States, while commercial and residential buildings in China make up 41.10% of total energy consumption. In Nigeria, residential buildings alone account for over 80% of all energy consumed (Adewumi A. O.-l., 2024). Ai (Ai, 2024) conducted a study titled " The impact of Smart city construction on labor spatial allocation: Evidence from China " using panel data from 2005 to 2020 and the Smart City Construction (SC) policy in China. The study utilized the Difference-in-Differences (DID) method to examine the impact of information construction on the spatial allocation of labor. The findings revealed that information construction significantly attracted labor and improved the spatial allocation of labor. After implementing the SC construction policy, the average increase in SC pilot labor was about 0.78 million people compared to non-SC areas. Furthermore, stimulating economic growth, improving the environment, and enhancing public services were mechanisms of the SC construction policy for labor's spatial allocation. Additionally, this policy effect has characteristics that vary by industry sector. The tertiary and secondary industry departments receive significant impacts.

Zaman (Zaman, 2024) discussed recent advances in the field of cyber cities for smart building management, highlighting recent updates to the pilot platform that enable further experiments in various smart city domains, aiming to improve energy conservation, transportation, building management, resilience, and sustainable infrastructure development. Lacson (Lacson, 2023) examined the assessment of smart buildings in developing economies, emphasizing the scope review due to a structured methodology, the ability to measure progress over time, and the potential for benchmarking against other cities. However, it's important to consider that every framework has its strengths and weaknesses, and cities might use multiple frameworks or adapt them to their specific needs. Our paper concludes by highlighting the importance of this research in providing comprehensive insights into smart city assessment in developing economies and the need for further studies to address identified gaps and enhance future evaluations.

As the integration of smart buildings in the construction sector increases, the need for proper management and energy dispatch at the building/area level becomes critical. Buildings must be able to balance their on-site energy production and consumption. Consequently, the traditional grid has been upgraded to a smart grid to cope with the increased penetration of solar and wind energy and manage its production. Following continuous global urbanization, the number of buildings (both residential and commercial) is increasing, whether in small cities or metropolises. In some global cities, nearly 50 residents arrive every hour for settlement (Adewumi A. O.-l., 2024).

Therefore, the aim of this study is to develop a new evaluation framework for " Ranking of Smart Building Design Factors with Efficient Energy Management Systems and Renewable Resources". It involves the intelligent use of sensors, actuators, information and communication technologies, and smart techniques and technologies to control and optimize the use of building resources (energy and infrastructure) and provide the best comfort for occupants. Buildings require sensors to obtain information about the building environment and available resources, which may include temperature, humidity, light intensity, airflow, and smart energy meters. Actuators are any item or device that can be controlled, such as light switches, windows, elevators, doors, air conditioning, ventilation systems, presence detectors, etc. Connecting all these elements is essential. This study also seeks to answer the question: How should the design factors of smart buildings with efficient energy management systems and renewable resources be ranked?

2. Research Methodology

The study on ranking the design factors of smart buildings with efficient energy management systems and renewable resources is an applied research in terms of its objective and a descriptive-survey study in terms of data collection. The study population comprised all academic faculty members in the field of architecture, based on information gathered from 112 architecture faculty members. Due to the small sample size, a census approach was adopted, meaning the sample size equaled the entire population. Consequently, after distributing and collecting the questionnaires, 93 completed questionnaires were obtained and analyzed. By using a census approach with the entire population of available faculty members, the study aims to enhance the internal reliability of the findings and minimize sampling bias. While the relatively small size of the population may limit generalizability to other groups, the comprehensive nature of this approach ensures a robust representation of the architectural academic perspective on smart building design factors.

Given the small size of the study population, a census approach was adopted, including all faculty members in architecture as participants. To further strengthen the representativeness and reduce potential sampling biases, participants were selected across diverse architectural specializations, academic ranks, and institutions. This diversity was intended to encompass a broad spectrum of insights and expertise related to smart building design, thereby enhancing the depth and applicability of the findings.

A researcher-made questionnaire was utilized in this study. The first part of the questionnaire included personal details (age, gender, marital status, education, etc.), while the second part was dedicated to ranking the design factors of smart buildings with efficient energy management systems and renewable resources. The questionnaire was categorized into four subscales: occupational factors, purpose-driven factors, lighting system indicators, and commitment factors. It was designed using a 7-point Likert scale. To ensure the face and content validity of the questions, feedback was obtained from several architecture professors who specialized in the field. Additionally, the construct validity of the questionnaire was confirmed through exploratory factor analysis, and its reliability was calculated using Cronbach's alpha coefficient, as reported in Table 1. For inferential statistical analysis, exploratory factor analysis and path analysis were employed.

Table 1: *The mean values, standard deviation, and reliability of the dimensions of factors influencing the attraction of design elements in smart buildings with efficient energy management systems and renewable resources.*

Factors	Number of Items	Mean	Standard Deviation	Cronbach's Alpha Coefficient
Lighting System	2	1.63	0.63	0.80
Fire Alarm System	5	1.60	0.40	0.83
Temperature and Humidity Sensors	2	1.02	0.39	0.84
Air Conditioning	7	1.62	0.48	0.89
Safety and Security	2	1.52	0.41	0.83
Audio and Video Control System	5	1.51	0.37	0.81

Exploratory factor analysis (EFA) was chosen as the primary statistical technique due to its effectiveness in identifying latent variables within the dataset without assuming predefined factor structures. EFA allowed for the extraction of the most influential factors that could guide the design priorities of smart buildings. This approach is particularly suited to exploratory studies, as it enables a data-driven analysis that reveals natural groupings among variables, which in this study, provided valuable insights into design factor prioritization for energy-efficient and resource-optimized buildings.

As shown in the results of Table 2, the Kaiser-Meyer-Olkin (KMO) test index is 0.980. Since the closer this index is to one, the more it indicates a high level of sampling adequacy, it can be concluded that the data is suitable for factor analysis. To determine the correlation among the items under study, Bartlett's test was used. The results of this test are also presented in Table 2.

***Table 2**: Kaiser-Meyer-Olkin (KMO) test*

Value	Description
0.980	KMO Index

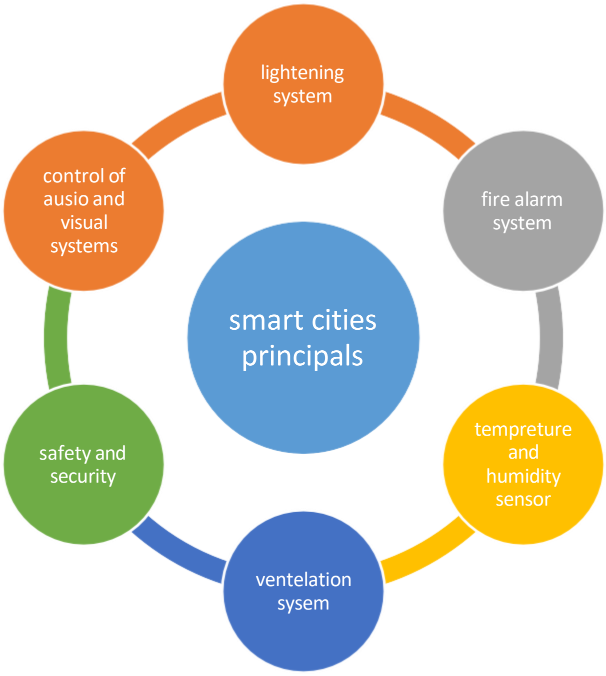

***Figure 1**: Conceptual model of the research*

3. Research Findings

To examine the identified needs, the exploratory factor analysis method was used. To assess the adequacy of sampling for factor analysis, the Kaiser-Meyer-Olkin (KMO) test was employed. The results of this test are presented in Table 2.

***Table 3** :Bartlett's test*

Value	Description
1102.011	Approximate Chi-Square Statistic
0.001*	Significance Level

**Significance level less than 0.05*

***Table 4**: Results of explained variances*

Factors	Eigenvalue	Percentage of Variance	Cumulative Percentage
Economic Factors	7.675	30.700	30.700
Social Factors	6.203	24.811	55.511
Environmental Factors	3.250	13.000	68.511
Physical Factors	1.798	7.191	75.701
Cultural Factors	1.425	3.152	78.853
Managerial Factors	1.325	2.170	81.023

As the results of Bartlett's test indicate in Table 3, given that the significance level is less than 0.05, the assumption that the correlation matrix is an identity matrix is rejected. Therefore, this confirms that conducting factor analysis is entirely appropriate for the data in this study. In the next section, the factors are extracted from the questionnaire items. Table 4 shows the results of the explained variances.

According to the results in Table 4, after performing Varimax rotation to better clarify the factor loadings, it was determined that six factors have eigenvalues greater than one and remain in the analysis. Based on the cumulative percentage column, it is shown that these six factors can explain 81.023% of the variability (variance) of the variables. The screen Plot in Figure 2 illustrates this point.

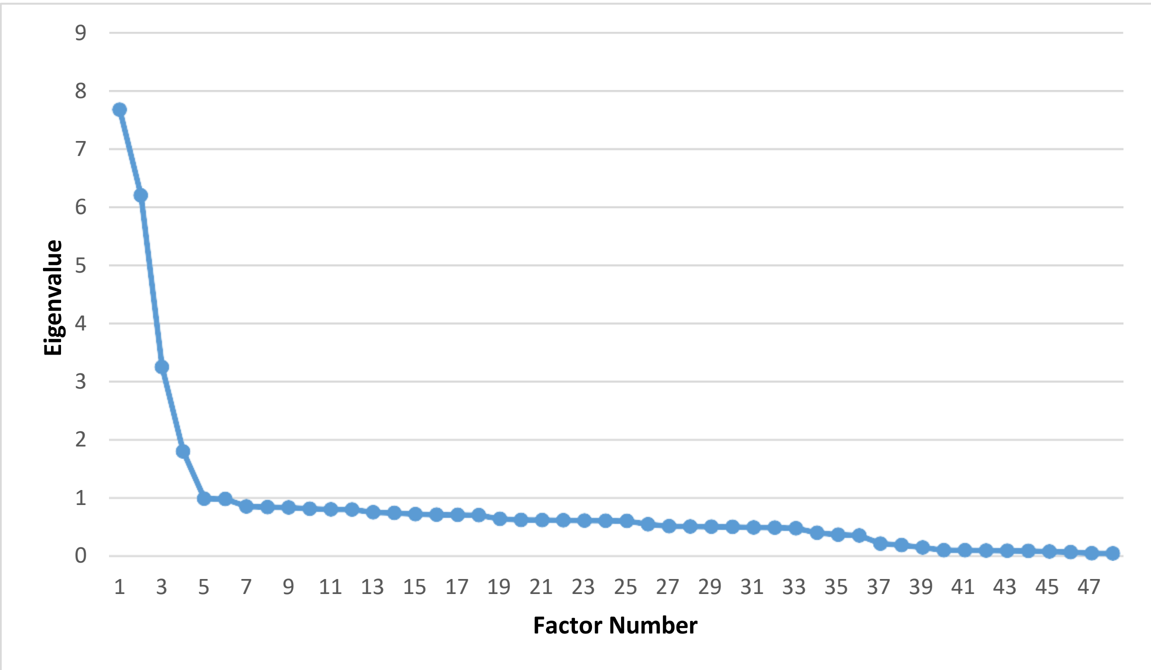

***Figure 2**: Screen Plot*

***Table 5**: The factor loadings of each item in the remaining factors after rotation*

No.	Statement	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
1	Does the use of smart lighting systems help manage renewable resources?	0.87					
2	Will the use of smart lighting systems save energy?	0.74					
3	Does the use of fire alarm systems in buildings help manage renewable resources?		0.65				
4	Will the use of smart fire alarm systems reduce human and financial losses?		0.52				
5	Does the ability to connect to other security equipment make the building smart?		0.84				
6	Will 24/7 building monitoring help make buildings smart?		0.63				
7	Will the use of fire alarm systems to detect fires help make buildings smart?		0.61				
8	Does the use of temperature and humidity sensors help make the building smart?			0.78			
9	Does using this system in smart buildings result in energy waste?			0.81			
10	Is the design and use of this sensor in enclosed spaces effective for making buildings smart?			0.83			
11	Is the use of this system effective in saving energy?			0.89			
12	Is the use of this system effective in air circulation in building spaces?			0.85			
13	Does the use of this system impact building temperature reduction?			0.65			
14	Will using this system in air circulation reduce bacteria in spaces?			0.70			
15	Are security systems effective in making the building smart?				0.62		
16	Do safety systems improve the quality level of buildings?				0.62		
17	Does the use of audio-visual systems help make the building smart?					0.67	
18	Does the use of audio-visual systems reduce energy waste?					0.74	
19	Does this sensor help save energy in smart buildings?						0.63
20	Does the use of these sensors help regulate temperature in buildings?						0.54
21	Does the use of this system help make the building smart?						0.59

Identifying the items related to each factor in the unrotated method is not straightforward. To enhance interpretability, the Varimax rotation method is used to rotate the factors. Table 5 presents the factors and items of the study along with their factor loadings after rotation.

As shown in the results in Table 6, the lighting system has the highest impact on smart buildings with efficient energy management systems and renewable resources, with an impact coefficient of 0.602.

As seen in Table 7, the overall research model demonstrates a good fit according to the goodness-of-fit indices. Figure 1 shows the impacts of the variables on smart buildings with efficient energy management systems and renewable resources. A one-sample t-test was used to examine this issue.

Table 6*: Effects of variables on smart buildings with efficient energy management systems and renewable resources*

Variables	T-Statistic Value	Significance Level	Direct Effect	Indirect Effect	Total Effect
Lighting System	15.531	0.001	0.602	None	0.602
Fire Alarm System	13.265	0.001	0.570	None	0.570
Temperature and Humidity Sensor	10.876	0.001	0.551	None	0.551
Air Conditioning	5.745	0.001	0.542	None	0.542
Safety and Security	4.701	0.001	0.523	None	0.523
Audio and Video Control System	3.324	0.003	0.501	None	0.501

Table 7*: Model fitting*

	Chi-square (X^2)	df	X^2/df	RMSEA	CFI	GFI	AGFI	NFI
Value	132.343	64	2.067	0.004	0.923	0.920	0.925	0.924
Criterion	...	Not less than 0	Less than 3	Less than 0.05	Greater than 0.90	Greater than 0.90	Greater than 0.90	Greater than 0.90
Interpretation	Good fit	Good fit	Good fit	Good fit	Good fit	Good fit	Good fit	Good fit

***Table 8**: Result of one-sample t-test*

Variables	Mean	Standard Deviation	T-Test Value	Significance Level	Mean Difference
Lighting System	3.17	0.47	3.46	0.001	0.17
Fire Alarm System	3.72	0.50	3.35	0.001	0.28
Temperature and Humidity Sensor	3.40	0.52	7.47	0.001	0.40
Air Conditioning	3.46	0.52	8.49	0.001	0.46
Safety and Security	3.19	0.44	4.13	0.001	0.19
Audio and Video Control System	3.60	0.60	3.20	0.001	0.23

Based on the results in Table 8 and the significance level of the one-sample t-test (0.001), which is less than 0.05, it can be concluded that the null hypothesis is rejected. This suggests that, according to the research indices, the implementation of smart buildings with efficient energy management systems and renewable resources should be adhered to.

4. Discussion and Conclusion

The results of this study align with the findings of Sharifi (Sharifi, 2024) and Zwick (Zwick, 2024) . These researchers found that renewable energies could lead to economic development and increased per capita income, which is consistent with the findings of this research. It has been found that with an average daily waste production of 1.3 kilograms per person, a sensor-based mechanism significantly outperforms the periodic survey approach by covering shorter distances with fewer trucks, while simultaneously achieving key objectives of cost efficiency, environmental preservation, public satisfaction, and reducing employee workload. This research contributes to the evolving field of smart building technology by providing vital insights for urban planners, policymakers, and technologists working to build more sustainable, efficient, and livable cities.

Sharifi (Sharifi, 2024) conducted a study that identifies and analyzes various business models employed in urban contexts through a systematic literature review and comparative analysis. The findings reveal a diverse range of models, including public-private partnerships, build-operate-transfer arrangements, performance-based contracts, community-based models, innovation hubs, revenue-sharing models, outcome-based financing, and asset monetization strategies. Each city uses a unique combination of these models to address its specific building challenges and priorities.

Lim (Lim, 2024), in a study aims to find empirical evidence of the positive and negative outcomes of smart city development. The Smart City Impact Index was developed with indicators across four pillars of sustainability (economic, environmental, social, and governance) and a technological dimension, as technology is the main driver of smart cities.

Zwick (Zwick, 2024) conducted a study focusing on the challenges of smart infrastructure. This research indicates that practitioners primarily perceive smart city buildings as a government-driven and data-driven effort, rather than vendor transactions , resident participation, or community partnership creation (Smart City 4.0), where specific technology takes a secondary role to the project's goals. We conclude that rather than moving through distinct generations, the smart city movement should be understood as a gradual process of modernizing municipal public management, as local governments become increasingly knowledgeable and experienced in contracting with technology companies to address urban problems.

José (José, 2024), in a study titled "A Review of Key Innovation Challenges for Smart Building Initiatives," found that qualitative results indicate there are 44 research articles reporting on the practices and outcomes of smart city innovation. The findings identify five main categories of challenges for smart city innovation: strategic vision, organizational capabilities and agility, technology internalization, ecosystem development, and cross-border innovation. This study also explores the relationship between these challenges and digital innovation practices in smart building projects. The main conclusion is that current innovation practices in smart cities are not well aligned with what the research literature typically describes as the core features of digital innovation, which may be one of the main reasons for limited progress in smart city projects.

Proper design and implementation of energy technologies and the built environment are critical for enhancing the energy efficiency and cost-effective performance of buildings and their connected systems to address global energy and environmental issues. Therefore, to achieve objectives while facilitating existing technologies and simultaneously meeting the needs and comfort of occupants within buildings, appropriate techniques and designs must be selected. In this context, a comprehensive review of the design and implementation of smart building energy and environmental systems was conducted and presented in this article.

To enable smart and sustainable homes/buildings in an energy-efficient manner, understanding the overall details of energy flow between a building and its connected systems (e.g., distributed renewable energy, energy storage, and electric vehicle systems) can be a critical aspect of future buildings at the community level. Furthermore, future smart buildings will fundamentally require advanced energy management and control systems that can provide efficient and cost-effective operations of the respective energy subsystems in parallel and be capable of integrating them into a communication network for real-time information exchange with others in the community and regional levels under various constraints, such as net metering, demand response, or carbon tax or credit, etc. Based on the current review study, it is recommended that future work focus on the implementation and case study of smart energy technologies in building, city, and community-level applications together in a practical application, considering the benefits of economic and environmental life-cycle analysis.

From the detailed literature review, the main conclusions and perspectives for future work can be highlighted as follows: from the review articles related to smart homes/buildings, this study identified that technologies in smart home/building applications are maturing, and the current research trend in smart homes/buildings is moving towards precise system integration or guidelines to enhance people's daily activities. The sustainability of the built environment, using recent advances in digital solutions (such as the Internet of Things), practical designs, and concepts in a cost-effective manner, addresses changes in people's lives and technologies while building connected systems.

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Measures of Information Visualizations in Design Studio Education: Designing Climate Change Visualizations

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Abstract: The climate crisis and sustainability are priority issues that are increasingly integrated into all fields of study in universities. For the field of communication design, there is a challenge to deliver effective designs on the climate crisis due to the complexity of the issue and the large volume of scientific data involved. To overcome this challenge, information visualizations are designed to help communicate complex data. Information visualizations, being data-driven, necessitate specific design principles in addition to fundamental graphic design skills. This study investigates the communication of the climate crisis through information visualizations, with the aim of determining the prominent measures and relevant design language that can be incorporated into design studio education. We conducted three focus groups with academics teaching communication design studios and professionals who have work experience in information visualization design and experts who are doing projects on sustainability and the climate crisis. The findings highlight the importance of actionability, enlightening, evoking curiosity, evoking emotions, localization, personification and positivity in designing effective climate change visualizations. This study contributes to the fields of information visualization and communication design by offering measures to enhance climate change visualizations and providing insights for teaching these principles in communication and graphic design studios.

Keywords: Climate change communication, Information visualization, Design principles, Communication design, Design studio.

1. Introduction

Climate change is a global issue that has significant local effects requiring public understanding and action (Climate Action, n.d.). The public's awareness of the urgency and consequences of climate change has grown as the effects are felt more directly (Peoples' Climate Vote, 2021) However, it is still challenging to communicate the scientific evidence on climate change to lay audiences. The challenge is due to “the issue's complexity and abundance of data” (Ballantyne et al., 2016, p.73) as well as people’s unfamiliarity with scientific contexts (Grainger et al, 2016). To address these challenges, universities are increasingly integrating climate crisis education across disciplines (Molthan-Hill et al., 2024), and in communication and design fields, there is a need to develop skills for translating complex climate data. In this regard, information visualizations have become a significant tool, helping to convey this data in a clear and accessible way, making it easier for the public to engage with and understand climate-related issues.

We organized three focus group studies with sustainability specialists, communication experts, and graphic design instructors in order to elicit measures and design language for effective climate change communication to lay audiences through information visualization. Our findings contribute to the fields of information visualization and communication design by offering principles to enhance the effectiveness of climate change visualizations and providing insights that can be integrated into design education.

2. Background

Effective communication of climate change has been a topic of interest since the second half of the 1980s with the initial communication revolving around scientific findings, conferences and decision-makers' meetings at the administrative level (Moser, 2010, p.32). However, as the global effects were experienced more and more and the scientific community witnessed how consistent the predictions in the IPCC scenarios were (Kurnaz, 2022), the need to communicate climate change to lay audiences has become a crucial issue.

Communicating scientific findings to lay audiences with the aim of setting them on action is increasingly being studied in the climate literature (Wu et al., 2023; Kumpu, 2022; Li et al., 2022; Agin and Karlson, 2021). Kurnaz (2022) suggested that "an intermediation or a translation between the language of the scientists and the language of general users" can help close the gap (p.224). There is a lack of mediators who would translate the knowledge and the need of information between the two groups (Kurnaz, 2022; Moser and Pike, 2015). Information visualizations can be mediating tools in filling the gap between lay audiences and scientists. In fact, DeCock-Caspell and Vasseur (2021) found that visualizations were an effective tool in engagement and knowledge mobilization of lay audiences. Information visualizations have also aided the communities in understanding of the complex issue of climate change and therefore paved the way for discussions, collaborations and an active role in decision making for lay audiences (DeCock-Caspell and Vasseur, 2021).

Information visualizations are tools of communication and there are different approaches to explaining communications's role (Ballantyne, 2016; Kumpu, 2022; Moser and Pike, 2015; Moser, 2010). According to some researchers, climate change is not just an issue to be addressed and communicated but it is an "ideological, cultural and symbolic issue" defined during the communication process (Kumpu, 2022, p.307). This approach puts forward that audiences have an active role in the communication process (Okoliko and De Wit, 2021). This perspective emphasizes that effectively communicating climate change requires more than just information—it involves engaging with audiences on many levels.

We argue that design plays a critical role in creation of effective information visualizations for lay audiences on the complex subject of climate change. As a matter of fact, "arts and social sciences can introduce a wonder to the ordinary truths within communication and engage audiences through incorporating senses and contemplation" (Carey, 2009, p.19). However, to design information visualizations that communicate effectively, we must begin by understanding the core qualities, or measures, that define their effectiveness.

2.1 Measures in information visualizations

The term measure refers to characteristics of an information visualization that define or explain what is a "good" information visualization. In the literature, terms such as cognitive concept (Borkin et al., 2016); quality (Quispel et al., 2016); factor (Kim et al., 2017; Quispel and Maes, 2014); criteria (Quispel et al., 2016) are used as well in place of the term measure. In this study we used the term measure similar to the term dimension or aspect; a particular part or feature of something.

The measures for "good" information visualization are memorability (Bateman et al., 2010; Borgo et al., 2012; Li and Moacdieh, 2014; Haroz et al., 2015; Borkin et al., 2016; Obie et al., 2019; Pena et al., 2020; Sezen et al., 2020), comprehension (Bateman et al., 2010, Obie et al., 2019; Chun, 2020), engagement (Boy et al., 2015; Haroz et al., 2015; Romat et al., 2020), clarity (Kostelnick, 2008), "accuracy, utility, efficiency" (Zhu, 2007), speed (Haroz et al., 2015), "attractiveness, soundness, utility" (Moere and Purchase, 2011), and enjoyment (Sezen et al., 2020; Romat et al., 2020). There is no consensus on the required measures of a "good" information visualization and the significance of measures vary according to different contexts (Torban, 2021; Popovich, 2021).

The studies by DeCock-Caspell and Vasseur (2021), Wang et al. (2018), Coelho and Mueller (2020), and Peña et al. (2020) highlight the importance of tailoring visualizations to specific contexts and audiences to achieve intended effectiveness. Therefore, it is necessary to further study measures of information visualization within a selected context. This study explores information visualization measures specific to the context of climate change communication.

2.2 Design Studio Education for Information Visualization

In design studios within communication and graphic design disciplines, students start off by learning the foundational elements and principles. According to Richard Poulin (2018), at the basic level, elements are the "whats" of the visual language; principles are the "hows" of this language. When elements and principles are carefully evaluated and used together, they enable the graphic designer to produce design solutions in an accessible, universal language. Without the proper application of basic elements and principles of design, visual communication would be ineffective and unable to "talk" to the target audience (Poulin, 2018: 10-12).

As a matter of fact, information visualizations make use of graphic design languages that have their foundations in perception principles (Poulin, 2018, p.9). Utilizing these principles, visualizations can improve understanding and engagement. Achieving a "good" information visualization requires an understanding of the design language, which in graphic design terms, includes elements/components that make up the visualization and rules/principles on how they all work together.

According to Ware (2010), skilled graphic designers use graphic design elements such as color, form, and space to aid the users in their visual quest for perceiving and making sense of an information visualization. In other cases, design teams follow a rigorous path to decide on a visual language; they employ user research, create explicit design systems, analyze competitors, find solutions to overcome cultural barriers, decide on a language and work a few cycles of design-test-redesign (Congote, 2022; Kuznetsov, 2020).

The design language depends on what is being designed or what is intended for the user to accomplish. For communicating a brand's identity consistency, clarity and cohesion come to the fore (Congote, 2022). In other cases, when the aim is to guide the user towards making comparisons, juxtaposition and symmetry are used (Aseniero et al., 2020; Legg et al., 2021). Design language can also aid communicating a message or a concept. Promann (2018) examined the displays of the devices that showed electricity consumption data and claimed that if data is presented by using proximity, a gestalt principle, people would see their own electricity consumption as a part of the society of which they were a part. However, data-driven information visualizations require specialized design principles, measures, alongside a graphic design language. In design studios focused on information visualization, students need to go beyond mastering foundational design elements and principles; they should also learn to apply specialized techniques tailored to data-driven contexts. While core design skills are essential, creating effective information visualizations demands an additional layer of expertise in principles specific to conveying complex data.

These include the aforementioned measures such as clarity, engagement, memorability…etc. Therefore, understanding and teaching these context-specific measures is essential for creating effective information visualizations tailored to diverse audiences.

3. Methodology

We conducted three focus group studies with subject-experts and academics to explore critical measures for climate change information visualizations and the essential qualities of a design language in line with the measures. The research question is:
RQ: What are the measures of an effective information visualization on climate change that should be incorporated into design studio education?

Eight experts participated in the first focus group study and their expertise is as follows: One of the participants was a data literacy expert who is one of the founders of Data Literacy Society (Istanbul) and holds a doctorate in media communication studies. A second participant was a communication expert who is an assistant professor in the Department of Media and Visual Communication, who had designed a course on climate change communication through animation. Two specialists from the Sustainability Center of the university who have been tasked with increasing awareness on climate change and other sustainability issues for students and university community attended the focus group study. There were also four graphic design instructors; one full time instructor, two part time instructors, and one associate professor in graphic design with experience in designing information visualizations. In the second focus group study, the participants were two graphic designers with 18 to 20 years of experience. The third focus group study included two graphic designers (with 20 years and 8 years of expertise) from an award-winning graphic design agency. The first focus group study was conducted face-to-face whereas the second and third focus group studies were conducted online over Zoom with the aid of Miro application.
The expert focus group studies were carried out in three consecutive sessions:
In Session 1, all the participants were asked to individually think about a question on how to communicate climate change to the public. After a few minutes, they were asked to join in a free discussion on the topic. The discussion continued for approximately 45 minutes. The authors of this paper took notes during discussions to share it in the following session.
In Session 2, measures of information visualization derived from the literature were presented to participants with short definitions of each measure. In addition, moderators shared their notes from session 1. The participants discussed the measures and contributed with additional measures they found significant for the topic of climate change and lay audience.
In Session 3, participants were presented with a sample of 104 information visualizations which were hung on a wall or presented over Miro application. They examined each visualization according to discussed measures and selected appropriate visualizations that exemplified each measure.

The information visualization samples evaluated in Session 3 were collected from social media (Instagram and X) and websites. The resource of visualizations are as follows: National news outlets (BBC Turkish, TRT Haber [Turkish Radio and Television], Anadolu Agency), digital news agencies (gzt, İklim Haber), non-governmental bodies (TEMA Vakfı [Turkish Foundation for Combating Soil Erosion], Greenpeace Turkey, Yuvam Dunya, Istanbul Climate Save, Change.org/iklim, 350 Turkiye, Ben de Buradayım [I am here too]), data visualization and social research companies (Konda Research, Doğru Veri [Right Data], Veri Kaynağı [Data Source], social media of commercial companies (Dohi Agriculture, Gıda Danışmanım [My Food Consultant] and one governmental organization (Meteoroloji Genel Müdürlüğü [General Directorate of Meteorology]).

The visualizations were collected from Instagram and X [Twitter] using the inbuilt search tool within the applications. The keywords used in the search included “climate”, “climate change”, “climate crisis” and “environmental issues” [in Turkish; iklim, iklim değişimi, iklim krizi, çevresel sorunlar]. To investigate the most current visualizations, the visualizations published between 2019-2023 were acquired. After excluding duplicates, 104 visualizations were left to be evaluated for this study.

The analysis was completed in three stages: In the first stage, two authors privately coded each focus group study. In the second stage, two authors privately categorized the codes from each focus group study. Then they discussed each other's categorization and reached an agreement on the categories. In the third stage, the authors worked together to theorize the themes by weaving back and forth between the raw data, the codes, and the categories (Coffrey & Atkinson, 1996). Each focus group is considered as a single data unit as the concepts for measures are generated together while participants have discussed and built on each other's ideas (Morgan, 1997).

4. Results

In this section we present the measures elicited in the focus groups; focus group study 1 (FG1), focus group study 2 (FG2) and focus group study 3 (FG3). Figure 1 (Fig. 1) shows the code categories used in the analysis process and Figure 2 (Fig. 2) shows measures in literature and measures derived in analysis.

4.1 Actionability

Actionability refers to the ability of the visualization to promote taking action and making decisions (Sorapure, 2023, p. 258). In climate communication literature, taking action is considered as a part of engagement with climate change on personal and public levels. On the personal level, engagement is more about dealing with mental obstacles in favor of behavioral change such as adopting an environmentally conscious way of life and taking part in decision-making processes; on the public level, the focus is on societal

Code categories	FG1	FG2	FG3
Actionability	●	●	●
Awareness-raising		●	
Emotive		●	●
Evoking curiosity	●	●	●
Eye-catching	●		
Eye-opening	●		
Gamification			●
Hopeful	●		
Illustrative	●		
Inclusiveness /inviting			●
Informative		●	
Instructive	●		
Localization	●	●	●

Code categories	FG1	FG2	FG3
Non-cliché	●		
Personification	●	●	●
Positive	●		●
Relatability to daily life			●
Sectioning		●	●
Sensational	●		
Sense of belonging		●	
Shocking		●	
Simplicification		●	●
Surprising (hook)		●	
Targeting		●	
Teaching	●	●	
Unsettling		●	

Figure 1: *Code categories used in the analysis process.*

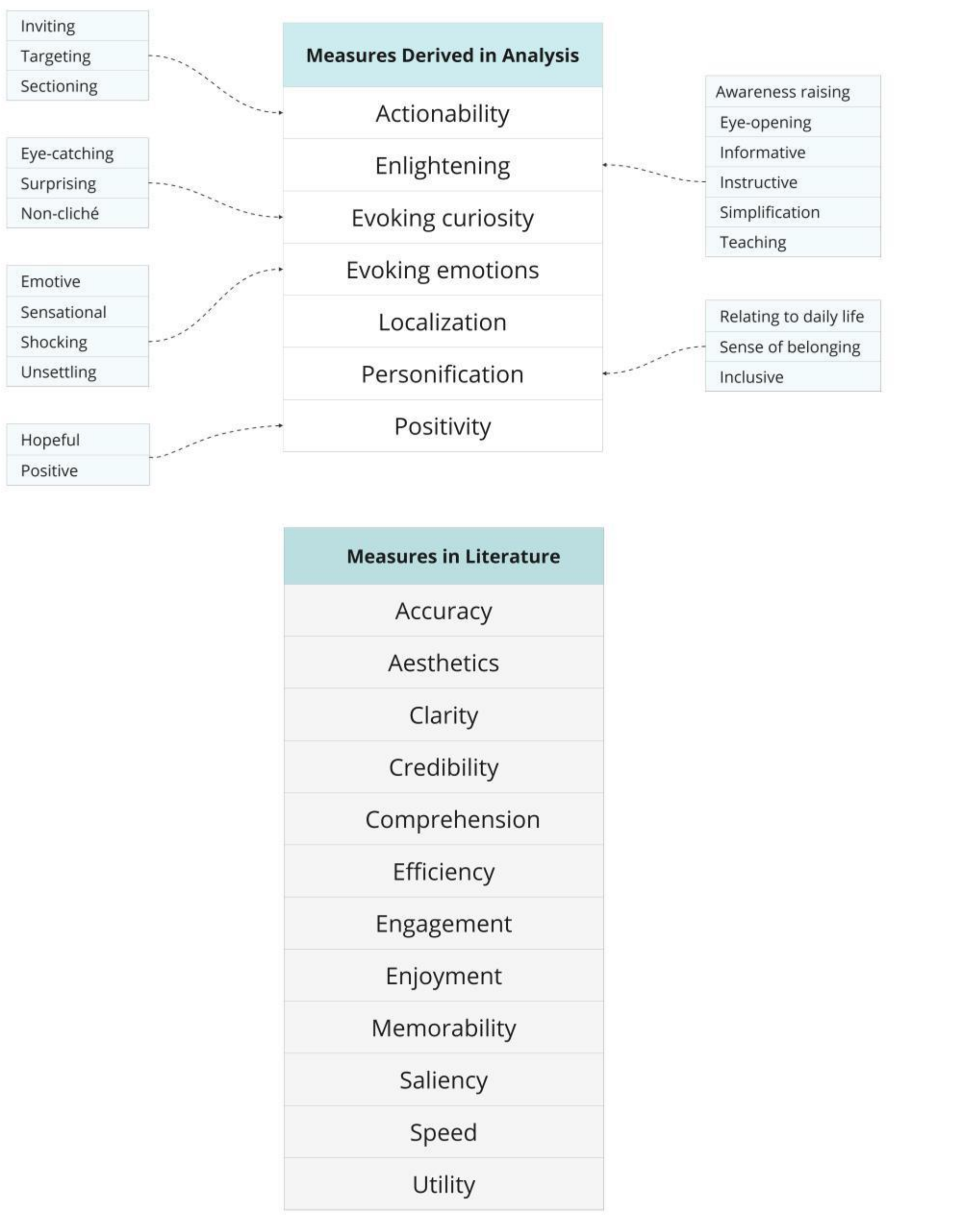

Figure 2: *Measures in literature and measures derived in analysis.*

transformation and the primary force behind this transformation is the political system (Kumpu, 2022, p. 307). In the focus group studies, the majority of the discussions on action taking were focused on the personal level.

In the literature, O'Neill and Smith (2014) underlined the power of visuals in illustrating the past effects of climate change and inspiring imaginations on the future of climate change. Wang et al. (2018) studied the effects of visuals and imagery on the engagement of general audiences in the context of climate change communication and concluded that images have a key role in public engagement. The researchers also underlined that there is no single solution for creating these visuals, as different goals and different audiences necessitate distinct strategies.

In line with the findings in the literature, participants suggested using realistic imagery to show possible risks and negative outcomes of climate change (FG1). They suggested that AI technology can be used to create images of the future scenarios. Visualizing possible future scenarios such as the rise of sea levels and its effect on the local geography may create a sense of urgency and also underline the seriousness of the climate crisis. Adding to that, realistic imagery is claimed to aid lay people to envisage the outcomes of climate change. This finding is similar to Ballantyne et al. 's (2016) study which shows that visual representations aid in clarifying climate change data, help lay people have a concrete understanding of the issue and provide a perspective to grasp uncertainties inherent to climate change (p.83). The overall idea is to include powerful images that will engage the audiences and also enhance their understanding of the impact of the crisis. The participants stated that the images can amplify the effects of the message. Through the use of powerful, captivating imagery, emotions can be evoked, an urge to take action may rise.

In addition, experts also mentioned information visualizations to be sectioning; dividing big chunks of information into digestible small parts (FG2 and FG3). The sectioning was explained by one of the participants through to-do-lists. To-do-lists from our daily life organize our chores and work so that it is less overwhelming for us to go through them (FG2). As we check the items we complete on our to-do-lists, the pile of things to do become manageable and taking action becomes easier, a sense of relief is felt. Similarly, another participant had pointed out that when they receive a design brief, they divide the brief into smaller parts. They organize the parts according to their importance and less important elements are omitted (FG3). Again, the idea is not to overwhelm, make understanding and taking action easier for the audience.

Two final components included under the measure actionability were inviting (FG3) and targeting (FG2). One of the participants stated that for an information visualization to be inviting, it should ask a question; questions help the audience reflect on the issue and participate in it by thinking about the answer to that question (FG3). This reflection can foster a sense of involvement, potentially motivating audiences to take personal action on climate change. On the other hand, a targeting aspect may also prompt action. Information visualizations with clear targeted messages may be pointing towards issues that the audience can take action on. For instance, an information visualization focused on the environmental impact of meat and dairy production can guide viewers toward this particular issue, making it easier for them to consider actionable steps (FG2).

4.2 Enlightening

The measure of enlightening comprises two components: educating and informing. Although the two concepts are used interchangeably in daily life, in the focus groups, it was discussed separately, as they required slightly different design considerations. We explain the two components below.

Educative quality of an information visualization is due to the context. Climate change is a complex topic; its reasons are complex and its effects are wide and complicated. First and second focus groups agreed that there is ignorance in the lay audience and having to consider this as a design input in climate crisis visualizations. “Foolproof visualizations” (FG2) and “designer’s awareness of the level of ignorance” (FG1) was deemed necessary for an effective information visualization on the climate crisis. That is, without assuming prior knowledge and by breaking down all complex concepts (FG3) is an approach that should be taken to make sure that the information is accessible to everyone.

Simplifying, clarifying and clearly explaining terms and avoiding intense terminology were key concepts discussed in FG1 and FG3. The issue of simplification was also discussed in terms of the language used within data visualizations. Keeping communication within the frame of daily language without overloading with domain terminology is suggested for promoting a better understanding. This is in line with research results of Wu et al. (2023) that suggest transforming professional and complex language into the everyday language so that lay audience can comprehend the issue and an emotional resonance can be generated.

It is suggested that designers should try to layer (FG1, FG2) the information. It is dividing the information into a few successive layers, beginning from the simplest facts and direct relationships to more complex dynamics. An example given is as follows (FG1): Instead of merely presenting a data chart about the decreasing rain levels per meter square, an information visualization can illustrate the relationship between decreasing rain per meter square with decreasing crop yields and then connect those to decreasing crop yields and food scarcity.

Participants in FG2 mentioned climate crisis concepts need to be explained in the information visualizations. Another suggestion is to make abstract concepts more tangible by use of correct metaphors (FG1, FG3). "...explain the results of [climate crisis] by illustrating tangible results such as draughts, floods, heat waves" FG3. Finally, the volumes, and sizes present in climate data are hard to grasp for human scale. A designer can visualize quantitative data in a relatable way. The concept of 100,000 hectares of forest can be difficult to grasp, but illustrating it by equating this area to the number of football fields can help lay audiences better understand the scale (FG1).

The component of informing is more about creating awareness about the events and processes that are related to the climate crisis. Designers are encouraged to create "eye-opening connections" (FG2) in information visualizations by use of appropriate metaphors and examples. In FG2, the discussion was on revealing the potential of individual actions by "flowing the information visualization to a person's daily life". A way of flowing into daily life can be to breach the taken for granted habits such as eating hamburgers (FG1).

4.3 Evoking Curiosity

Climate change has been in the media for decades now. There is an abundance of information visualizations in the media. Focus group study 1 participants pointed out that visualizations such as fish in a dried, cracked lake bottom or a bird walking on a cut-down forest floor have been used so many times that they became "cliché". Today such information visualization designs can make people get bored and non-responsive. They argued that there is a growing climate change blindness in people, borrowing the concept from ad-blindness on the web. Their suggestion was to find original ways to visualize information, by use of metaphors, images and illustrative styles.

An example suggestion was to create an illustrative information visualization about the consumption of one thousand liters of water to produce one liter of cow's milk. One of the participants suggested that using a hand-drawn illustration of a cow taking a bath in a tub would be both attention grabbing and also underline the big amount of water required (FG1). The hand drawn lines and hand-written-style font would make the whole design more personal and intimate, promoting a personal reflection on the issue. A similar remark was put forward by another participant about creating a visual hook to grab the attention of the audience (FG2). Since people's attention spans are decreasing, a shocking hook in the design would be pulling in the audience to the information visualization.

4.4 Evoking Emotions

In all the focus groups, the emotional effect of the visualization design on the audience was discussed as a critical point. This is because "works which trigger emotions get more reactions" and "people form connections with the subject" (FG2) and could "activate people" (FG3). Among the 104 visualization samples designed just to convey information were found to be less effective in terms of conveying the message (FG3). The samples that targeted emotions (and thus effective ones) were described as "sensational" (FG1), "disgusting"

(FG3), “depressive” (FG3), “frightening” (FG2), “optimistic” (FG1). Participants explained that the above emotions in the information visualization samples were evoked by use of color palette, type of images and the word selections in the texts.

On the other hand, there was no consensus on the type of emotions that should be targeted by designers. FG2 participants argued that targeting ‘blind’ emotions are very important and invoking fear is a common strategy in climate crisis communication. On the other hand, FG1 participants reached an agreement on avoiding fear as it creates eco-anxiety which in turn causes people to stop trying. FG3 participants did not suggest use of any pecific emotions but they emphasized that in order to create a connection with the audience, to convey messages effectively and finally to trigger people, the designs should definitely incorporate emotional dimension.

4.5 Localization

Localization was considered as a powerful tool to consider in design decisions in two focus groups. In focus group 2, participants argued that the communication strategy in previous years proved to be ineffective as no local consequences were presented. They said that “...the images of polar bears swimming in melted arctic ice caused the climate crisis to be perceived as a far and away situation…we need to use images and metaphors that exist here”. In focus group 1, it is suggested comparing the home country with other countries or the world as a method of localization. Geographical comparisons may help lay audiences to understand the situation in their local city or country in relation to the global situation. This train of thought is supported by a study in the literature as well. DeCock-Caspell and Vasseur (2021) found that local people were more engaged and were able to comprehend how the climate crisis is affecting the environment when they saw aerial photographs of their local coastline. It can be said that people in various countries have similar traits for understanding the climate crisis.

Another way of localization is to consider local culture in the design of information visualization. In focus group studies 1 and 2, participants suggested that targeting traditions and customs can have a strong effect. However, the suggested approach in the two focus group studies were opposite of each other: The first one suggested focusing on negative effects of the local customs on climate (FG1), whereas others cautioned about ‘attacking’ them (FG2).

4.6 Personification

We are contributing to climate change with our modern, conspicuously consuming lifestyle. The experts in focus group study 1 emphasized the importance of individual actions, even if they are miniscule compared to the scale of the issue. In focus group studies 1 and 2, it is argued that explaining the negative effects of an individual’s everyday habit can help people relate to the climate crisis more easily. Through relatable examples, lay audiences may realize the role of the individual and seek for solutions. A simple flat illustration of a hamburger’s layers and the amount of water spent to produce that layer is an everyday example (FG2). The simple design of the illustration targets the non-scientist audience. The content of the illustration matches the consumption habits of fast-food consumers in Turkey; as stated by Deniz and Abbasaliyeva (2022) 59% of the fast-food consumers in Turkey prefer eating hamburgers.

Relating to daily life was also mentioned by participants in the third focus group. By providing examples from daily life, an information visualization may enable the audience to connect with the issue on a more personal level (FG3). Real stories from everyday life, even very simple acts of recycling may help audiences to see that every personal action counts and the individual can make a positive impact with even small contributions (FG3).

In addition to creating connections through examples from daily life, creating a sense of belonging (FG2) also establishes a connection between the individual and the climate crisis. Situating the audience as part of their neighborhood, then expanding to the city, the country, and ultimately Earth, could foster a personal connection to the environment and therefore inspire a sense of responsibility and motivation to engage in sustainable actions.

4.7 Positivity

In FG1 and FG3, participants suggested keeping a positive and hopeful design language in communicating climate change to lay audiences. They discussed that when faced with the harsh realities of climate change, being positive can be a very effective strategy to stay clear of any potential negative emotional effects, such as eco-anxiety (FG1). The negative emotions of stress, helplessness, anger or fear brought on by awareness of environmental problems are referred to as eco-anxiety. Instead of overwhelming lay audiences with the impacts of the climate crisis, focusing on possible solutions and actions, promoting hope may support sustainable behavior. The participants pointed out one of the good examples by commenting “this one focused on accomplishments rather than warning about the consequences, this is a positive information visualization” (FG3).

Positivity does not mean putting aside the urgency or the seriousness of the issue. In fact designers need to attain the delicate balance between anxiety and urgency (FG2). It is about framing the communication in a constructive and actionable way to make sure lay audiences have motivation and empowerment to act upon the information they acquire through the data visualizations.

5. Discussion and limitations

This research focuses on information visualization measures specific to the climate crisis context, therefore mentions of the existing information visualization measures were not coded during the analysis. Note that existing measures were not rejected by participants when we presented them in the focus group sessions. Therefore, we take accuracy, aesthetics, clarity, credibility, comprehension, efficiency, enjoyment, engagement, memorability, saliency, speed and utility as valid measures for climate crisis context. On the other hand, we suggest additional but specific measures to teach for the information visualization design for climate crisis context. We suggest enlightening, evoking curiosity, evoking emotions and personification measures. In addition, we elaborate on how to employ actionability (Kumpu, 2022; Wang et.al., 2018), positivity (Parry et.al., 2022) and localization (DeCock-Caspell and Vasseur, 2021) for information visualization designs. Actionability, positivity and localization concepts are mostly found in climate crisis communication studies. The three concepts were strongly emphasized as measures in all three focus group studies.

We observe a tendency in the information visualization studies for isolating graphical design elements (e.g., icons, colors) in order to study their effects on measures like memorability (i.e. Haroz et. al., 2015). However, design is more than the sum of its parts. An information visualization overloaded with icons, for example, might confuse rather than clarify. Similarly, the harmony between various elements can significantly influence the overall effectiveness of the visualization. Therefore, this study adopts a holistic approach, considering design strategies and language in their entirety rather than isolating individual elements.

In the literature, there is a growing number of studies in interactive information visualizations (Walker et al., 2020; Herring et al., 2017; Neset et al., 2016) to increase the understanding of climate change and community engagement. Herring et al. (2017) found that interactivity led to considerable shifts in beliefs and attitudes of the lay audience (p.102). On the other hand, Newell et al. (2016); compared static and interactive visualizations on climate change regarding the measures of audience interest [engagement] and understanding [comprehension]. They concluded that interactive visualizations were more engaging but static ones were more useful for obtaining detailed information on the issue. Climate change related information visualizations for lay audiences are mostly shared and accessed on web and social media platforms. Although the platforms per se are interactive, the information visualizations shared within them are actually static. The lay audience in question experiences information visualizations as static visual artifacts. As a result, interactive visuals were out of the scope of this study.

Information visualization literature often approaches visualizations from a practical and perception/cognition standpoint, emphasizing measures like clarity and speed, largely rooted in the discipline of psychology. However, throughout the focus groups, the experts prioritized measures such as personification, localization and actionability which consider audiences not as an isolated group in a vacuum but as culturally situated individuals with different views, beliefs and backgrounds. In the focus groups, the perspective was from the audience's active process of meaning-making rather than mere perception of information visualizations. In the real world, when an information visualization is presented, audiences play an active, rather than passive, role in constructing the meaning (Okoliko and De Wit, 2021) of that design. As a result, our findings align with the communication design approach rather than a cognitive psychology approach.

The findings of this study are based on expert opinions gathered through three focus group studies. Future research should increase the number of studies, as well as that they should include participants from NGOs who actively strive to communicate the climate crisis to the public. Further studies are needed to examine the effect of information visualization design decisions through empirical user research. Gaining insights into how various audiences view and engage with visualizations can help improve communication about climate change.

6. Conclusion

This research provides an exploration of the measures for designing information visualizations in the climate crisis context that can be utilized in teaching design students. We conducted three focus group studies with communication design academics, design professionals and sustainability experts. We identified actionability, enlightening, evoking curiosity, evoking emotions, localization, personification and positivity as specific measures in information visualizations about the climate crisis. We suggest design education for information visualization should incorporate the aforementioned measures in projects regarding the climate crisis.

Through captivating imagery, targeted designs and inviting content, actionability focuses on encouraging the audience to take personal and public level actions on the information provided. Educative content designed for audiences with all levels of knowledge on the climate crisis, simplified and clear explanations and awareness raising informative approaches make up the enlightening measure for effective information visualization designs. By avoiding cliché imagery and including eye-catching illustrative styles may evoke curiosity and surprising hooks can enhance audience attention. Whether it is frightening or hopeful, an information visualization should evoke emotions to convey the importance of its message. Localization helps make the information relevant to the audience's local context, supporting personal connection and relevance. Positivity helps maintain engagement and motivation, lowering the risk of eco-anxiety while finding a balance between paralyzing negative feelings and urgency. Personalization makes the issue relatable by connecting it to the audience's everyday life while creating a sense of belonging for individuals within a public-embracing approach. By focusing on these specific measures, the research provides a comprehensive set of measures that can be incorporated into design studio education on information visualizations; for impactfully bridging the gap between scientific data and public understanding.

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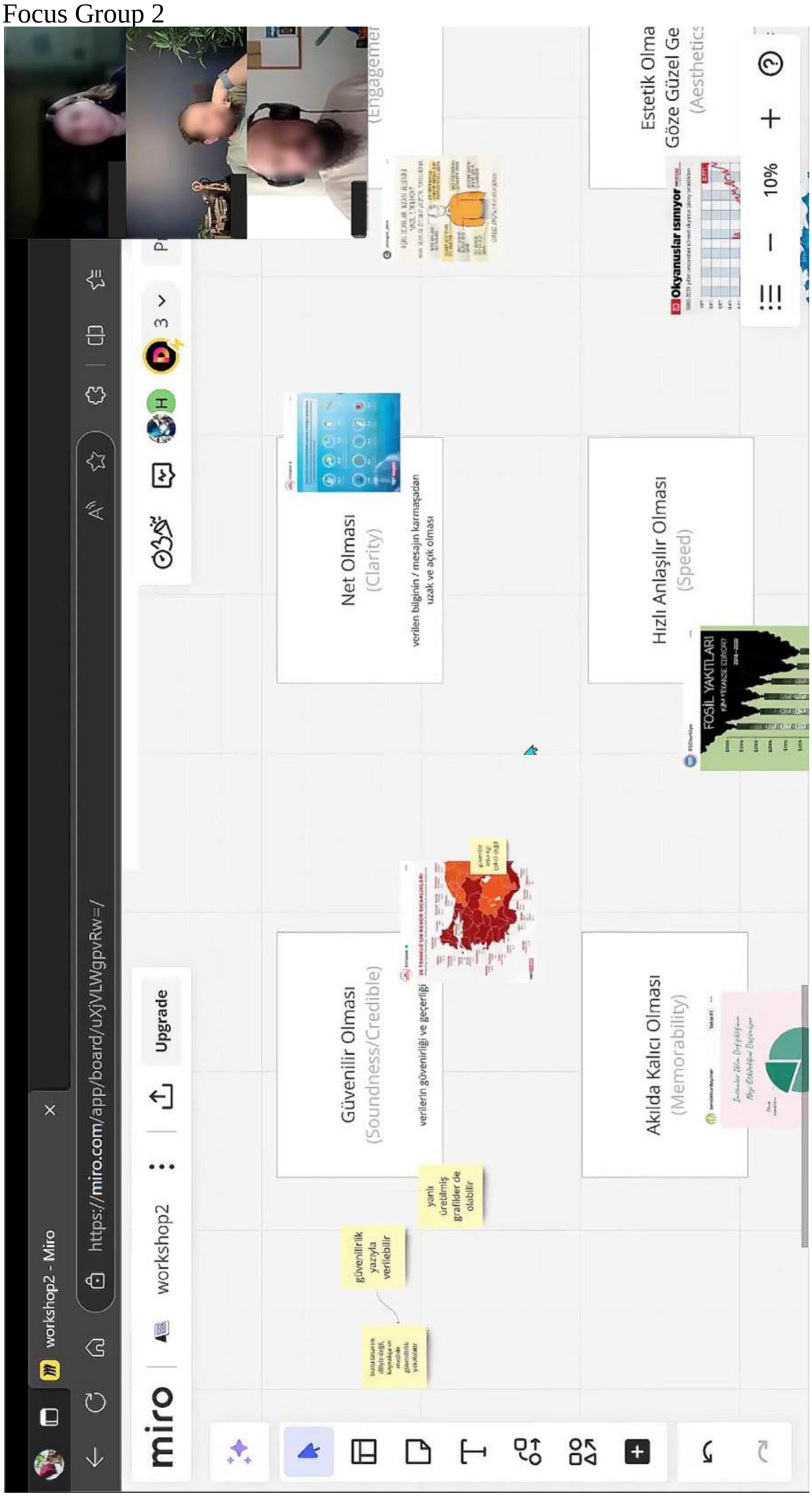
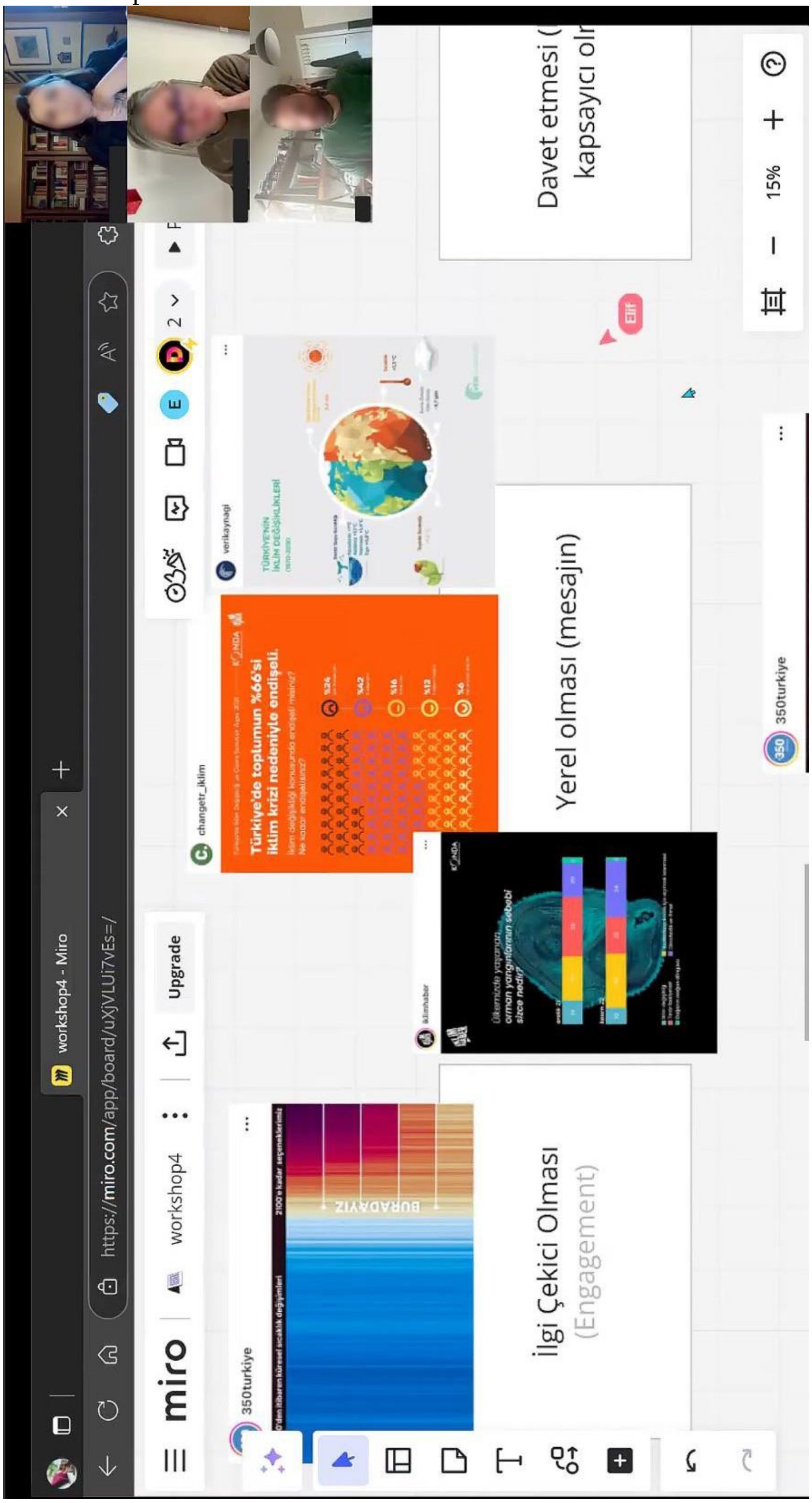
Appendix

Photographs from the conducted focus group 1.

Focus Group 2



Focus Group 3



Sample codes from analysis process on Miro.

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A Comparative Study on Philosophy, Epistemology, and Methods of Teaching in Design Studios in the Beaux Art, Polytechnique, and Bauhaus: Regeneration, Development, or Transformation?

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Abstract: This paper aims to investigate some philosophical and epistemological foundations in collecting knowledge in three important schools of architecture including Beaux Art, Polytechnique, and Bauhaus. Those three schools not only had differentiation in the time and location but also different ontological views of the built environment. Despite the less philosophical arguments on the architecture education, the curriculum and structure of the design studios (ateliers) referred to the beliefs, ideology, and philosophy even though they were not explicit. The content analysis, logical argument, and interpretation techniques were applied in this research to compare, investigate, and analyze the content of design studios and curricula to demonstrate the epistemological approach and the philosophical foundations in those three schools. The findings of the research show some linkages between the contextual and philosophical movements in the times of the schools and the structure of teaching. The effective philosophical foundations in those schools included neoclassicism, idealism, and romanticism for Beaux Art, rationalism, empiricism, and functionalism for Polytechnique, and socialism, modernism, and constructivism for Bauhaus. While it was not possible to draw a distinctive line between other philosophical thoughts from the schools, however, those philosophical schools were more related. In conclusion, the research realized a significant connection between four factors that form any architecture school, curriculum, and studio including philosophical and ontological context, epistemological discourses on knowledge, architecture projects and context, and architect's beliefs and ideology. These four factors orient architecture education. The results could be useful for architecture schools, which will guide the other schools to select their orientation in the future.

Keywords: Philosophy, Epistemology, Design studio, Beaux Art, Polytechnique, Bauhaus.

Introduction

Architecture education has been an open discourse in different institutions to be appreciated or criticized based on styles, methods, and approaches. There are many studies to appreciate the application of different topics, (Goldschmidt, 2002); reflection-in-action (Schon, 1984), research (Franz, 1994; Frayling, 1993; Groat & Wang, 2002) or approaches in curricula and design studios; (Park, 2020; Schon, 1984). On the contrary , there are many critics of architecture education and training such as an unmodern style (Garric, 2017), a set of rules (Griffin, 2022; Littmann, 2000), far from research (RIBA, 2014), and a complicated curriculum (Jones, 1981). Nonetheless, architecture's methods in education were celebrated by great philosophers such as Hegel in terms of the creation of the most completed form of art (Fields, 2000; Karatani, 1995). Probably, it is related to the varieties of educational styles in architecture that formed such kinds of diversities.

This variety of educational styles can also encompass a wide range of varieties from a more conservative to an Avant-garde approach in schools of architecture (Tafahomi & Chance, 2023). Despite the trend to call architecture in terms of discipline, architecture has been one of the multidisciplinary fields of study, knowledge, and skill that is interlocked with art, philosophy, science, and education (Karatani, 1995; Marder, 2017). For example, Leonardo Da Vinci (1452-1519) defined the architecture as an amalgamation of art and engineering (Stephen, 1962) which fundamentally needs drawing skills and art knowledge (Tafahomi & Chance, 2023) or Hegel (1710-1831) defined architecture as a conjunction point to connect art and philosophy through aesthetes (Tafahomi, 2023).

Training of the students in the architecture profession has a long history; and three major architecture educational movements discussed in this paper have been so effective on the current style of education in terms of teaching and learning styles in architecture schools that in some way all instructors inherited those styles or skills through observing, participating, training, or reading. The Beaux Art, Polytechnique, and Bauhaus are three major schools of architecture that challenged, changed, and advocated specific architectural styles in different times and locations. While these schools of thought in architecture have been rooted in the history and philosophical context (Proudfoot, 2000) of Europe; however, those schools effected deeply the architecture education in around the world (Laroche, 2008; Littmann, 2000) and to date there are some universities that maintain those styles and orientation (Tafahomi & Chance, 2023).

The Beaux Art, Polytechnique, and Bauhaus schools have been under celebration and criticism in over time, also in the same time, and they have their own fans, supportive people, and educational styles. Those schools have been a role model for the many architectural schools for a while (Draper, 1977; Fox, 2013) such as New Zealand (Madanovic, 2018), USA (Littmann, 2000), Greek (Armstrong, 2016), Egypt (Ramzy, 2010), and East African countries and Iran (Tafahomi, 2021). The level of effectiveness of each school refers to the model of teaching and the responsiveness of those schools to the time of location (Doyle, 2016; Mindrup, 2014). Garric (2017) mentioned that each architecture school not only creates its own spirit, system, and culture of teaching but also establishes its own ideological system of thought to train the students. In this regard, it is of great importance to know the philosophical foundation, teaching methods, and approaches (Dennen, 2004; Lupton & Miller, 1993) of those architecture schools that appeared in the courses, design studios activities, and projects.

The philosophical foundations of those three schools and their teaching approach have been rooted in their viewpoint on architecture, education, and the world. The term philosophy means the "love of wisdom" about knowing human 'existence' and 'experience' (Britannica, 2024). Philosophy is defined as a process of critical examination of beliefs and logic (Britannica, 2006). Kemmis and Groves (2018, p. 116) defined the philosophy in education in terms of "a good set of knowledge for the practice to be learned by individual, humankind, and society". It takes place through saying, doing, and relating all together in a project (Schatzki, 2010). For example, François Blondel (1618-1686) as a teacher in the Beaux Art mentioned that the mission of the Beaux Art in education is 'absolute classicism' (Griffin, 2022). Such kinds of expression refer to the philosophical foundation, beliefs, and ideology that appears in the expression. The philosophical thoughts have had a significant role in distinguishing those schools from other styles of construction and masonry (Tafahomi, 2023). However, the critique theorized that architecture practice is more ontological than epistemological to know about it, and it is a differentiation between architecture and other fields of engineering (Kemmis & Groves, 2018). Social, political, and philosophical contexts of the architecture institutions have been very effective on the arrangement of the educational materials, contents, and instructions (Kemmis & Groves, 2018; Tschumi, 1996).

Fox (2013) indicated that the architecture job before the new generations of architectural institutions such as the Beaux Art's graduated students focused the building construction and management rather than design. However, with the new generation of architects, projects, and sources the new form of architecture education, projects, and ideas are expanded. At any architecture school, the question will be about different aspects of knowledge that are celebrated, produced, and applied in the school. This applied knowledge in terms of epistemology was always questioned (Jones, 1981). For example, the study highlighted that some of the philosophical influences of Bauhaus took time to appear in educational systems in the US through practitioners (Langmead & Garnaut, 2001).

Despite the studies on the history of architecture, the history of the educational centers and schools was discussed briefly (Tafahomi & Chance, 2023). Some of studies attempted to highlight specific aspects of the education, training, or projects in those schools (Bokov, 2021; Carlhian, 1979; Cunningham, 1980; Doyle, 2016; Draper, 1977; Garric, 2017; Griffin, 2022; Madanovic, 2018; Proudfoot, 2000). Kemmis and Groves (2018, p. 124) classified architecture education in three aspects "cultural-discursive arrangements, material-economic arrangements, and social-political arrangements" that refer to the belief, knowledge, and context of the education. Nonetheless, belief, knowledge, and context indicate philosophical foundations that were interpreted by Schazki (2010) in terms of ontological aspects of architectural products. However, there are a few comparative studies, and even rare philosophical analyses (Kemmis & Groves, 2018; Ramzy, 2010). Nonetheless, the Beaux Art, Polytechnique (s), and Bauhaus schools trained great architects who changed architectural projects, knowledge, and studio styles during their period. Those schools established particular methods and manners in their education that are called as style, school, or tradition. They have had similarities and dissimilarities in the themes, topics, and methods that made them schools of architecture with specific character and identity. Despite the quadruple theories on architecture educational styles including architects, architecture projects, architecture knowledge, and architecture context (Long, 2017) (Figure 1),

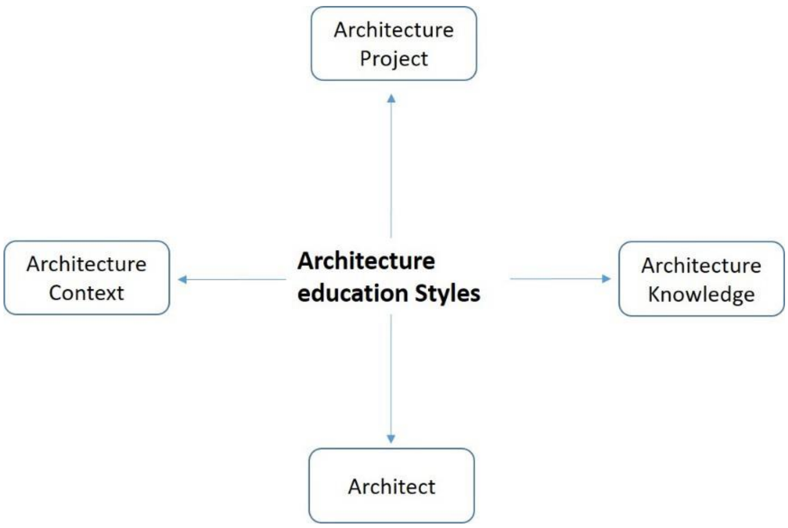

Figure 1: *The effects components in the architecture education*

seemingly there are more important factors that lead the studio studios philosophy.

The research questions in this paper are designed as what is the relation between the philosophical context and architecture program at the time? What sort of knowledge was celebrated and applied? What courses and modules represent the ideas of the instructors in the program? And how do those aspects affect today's teaching tradition? The objective of this research is to trace the philosophical approach of the architecture programs in different periodsand locations to compare acquisitions of knowledge and the application in the courses particularly in design studios. In this frame, the three architectural schools are analyzed through on content analysis, logical argument, and historical review.

Methodology and Research Design

This section explained methodology, research design, process, and relevant data.

Methodology

The qualitative method was applied widely in historical studies (Denzin & Lincoln, 2018; Given, 2008; Silverman, 2010). Qualitative method was oriented to describe, explain, or analyze the phenomena in the context deeply (Creswell & Creswell, 2018; Ezzy, 2002; Groat & Wang, 2002). There are some levels of interpretation in qualitative methods (Krippendorff, 2003) in applying for the deep analysis of the data (Groat & Wang, 2002; Neuman, 2006). The qualitative methods in architecture areas were applied through graphical analysis (Ching, 2015; Crowe & Laseau, 2011; Laseau, 2000; Tafahomi & Nadi, 2021), descriptive (Chiarella, 2005; Mugerauer, 1995), analytical (Carmona, 2001; LaGro Jr, 2008; Lang, 2005), research by doing (Adams, 2008; Boradkar, 2010; Goldschmidt, 2002; Koskinen et al., 2011). A few studies referred to the philosophical aspects of architecture (Franz, 1994; Groat & Wang, 2002; Tafahomi, 2022a; Wang, 2006). Content analysis, logical arguments, and interpretation have been common techniques in the qualitative method to analyze historical and comparative studies.

The content analysis technique was applied in analyzing the texts, speeches, images, and maps to discover meanings, themes, and similarities (Krippendorff, 2003; Schreier, 2012). This technique commonly utilized in built environments. For example, Carmona (2001) applied content analysis to discover the urban design qualities in the housing policies in the UK. Lang (2005) used the techniques to compare 50 urban design projects in the US to classify the common aspects in those plans. In a similar study, Bently et al (2003) drew a guideline for the design through prior design documents. The study indicated a variety of applications of this technique in architecture, urban planning, urban design, and landscape (Tafahomi, 2022a).

Logical arguments were mentioned as a process for the theoretical discussions on the specific topics in architecture research (Groat & Wang, 2002). The logical arguments were applied to explain theories in architecture (Pallasmaa, 2005; Schon, 1984), urban planning and design (APA, 2006), and landscape (Spirn, 1998). The logical argument was defined as a way to understand elements and things through explanation (Grimm, 2011) to expose the meaning through a new interpretation (Hancock, 1995; Seamon, 2015). Interpretation was also mentioned as part of the logical arguments to interpret, explore, and discover sets of meanings (Barker, 2005; Dreyfus & Rabinow, 1982; Jin, 2021) in texts and elements in historical studies and to expose the relationships for new sets of meanings (Mugerauer, 1995; Norberg-Schulz, 2019).

Research design

The qualitative method was the most relevant technique to analyze the content of the sources of studies about the three schools of architecture at different times and locations. This research applied content analysis, logical argument, and interpretation techniques based on qualitative methods to describe, explore, and define the teaching process in those three schools (Creswell & Creswell, 2018; Given, 2008; Groat & Wang, 2002; Tafahomi, 2022a). Those techniques applied to discover the philosophical foundations (Proudfoot & Lacey, 2010), knowledge (Crumley, 2009; Grimm, 2011; Rescher, 2003), and teaching styles (Carlhian, 1979; Kavuran & Dede, 2016; Lerner, 2005). The content analysis was utilized to analyze the documents concerning the three architecture schools to extract the applied themes, topics, and approaches in the schools (Carley, 1990; Drisko & Maschi, 2016; Elo et al., 2014). The related documents about those three schools included historical books, critical papers, and reports as sources of data (Krippendorff, 2003; Schreier, 2012).

The logical argument and interpretation techniques were used to explain the relationship between different aspects of those three schools of architecture in the philosophic context in terms of predominate schools of thought in the time and location of the applied knowledge (Groat & Wang, 2002). The logical argument explored to demystify relationships between the educational materials, knowledge, and approaches they applied.

The interpretation technique was employed to ascertain the meaning of the documents, reports, texts, and design styles (Krippendorff, 2003; Mayring, 2000; Schreier, 2012) in those schools through making a "mapping of meanings" (Barker, 2005, p. 85; Jin, 2021), layers of meanings (Gomez, 2003; Seamon, 2015), or structure of meanings (Dreyfus & Rabinow, 1982; Hancock, 1995; Mugerauer, 1995; Park, 2020). The meaning for three different "meanings" indicated the changing behaviors and beliefs during the time, to explore hidden meanings behind the activities and traditions, and relations between different elements of the meanings, respectively.

Research process and data

To analyze the transformation of architectural education during the time, this research started to explore the foundation of the first generation of architecture schools through the Renaissance and Enlightenment movements. This research explored the effects of those movements on the architecture schools' structure importantly philosophical approach as a manifesto, applied knowledge as an epistemological view, and structure of program and delivery in the schools due to the documents and data. All applied data in this research were combined from documents, sources, critical papers, reports, and images or drawings. For this reason, perhaps the research missed some of the sources that could open a new perspective. However, at the same time, this problem could create an open discussion for the folk to start to write their critiques about this structure and it could continue to enlighten the topic.

Critical Discourse on Three Schools of Architecture

The architecture schools in the 17th and 18th centuries faced many social, economic, and political transformations that were rooted in the philosophical movements through Renaissance and Enlightenment movements. The Renaissance freed art, philosophy, and science from the pressure of the religious dogma. The results of the Renaissance were defined in terms of a journey from macro to micro exploration (Brotton, 2006) and as a rebirth of culture in terms of "the beauty of nature and the dignity of mankind" (Merriman, 2010, p. 44). The Renaissance constructed a platform for the Enlightenment era with some philosophers such as Edmond Bacon with empiricism (1561-1626), René Descartes with methods (1596-1650), Baruch de Spinoza with naturalism (1632-1677), John Locke with epistemology of knowledge (1632-1704), Isaac Newton with mathematics and physics measurements (1642-1726), David Hume with skepticism (1711-1776) to form rationalism era (Lacey, 1996; Proudfoot & Lacey, 2010).

Before the Renaissance and Enlightenment movements, education in different fields of knowledge took place through religious schools or apprenticeship activities (Labaree, 2008). There were few universities around the world (Verger, 1992). In the architecture school case, Broadbent (1995) referred to the Academia Platonica in Florence as the first private school of art and architecture that trained the students through apprenticeships in the school based on the application of Vitruvian theories to train the architects in the time. Achievements of the Enlightenment movement resulted in the institutionalization of educational centers as the main component of the policies. Frijhoff (1996) mentioned that the demand for technical schools increased due to industrialization in Europe. Many of the colleges and the technical universities took the birth to be independence from the central university and government in the south of Europe to involve other social classes rather than nobles and aristocrat families (Vandermeersch, 1996).

The Enlightenment context with rationalism, natural laws, reasoning, and methods led countries in Europe to do the institutionalization for the "depersonalization" of education (Schwinges, 1992, p. 172). Despite the disagreement in the classification of architecture and medicine either as art or earth science in Middle-Age time, the Renaissance and Enlightenment led the architecture programs to be established as individual institutions or be part of technical programs. The disagreement was constructed based on the definition of Virtuous from architecture in terms of the art of building including art, theory, and construction (Ruegg, 1992). The first school of architecture after the Enlightenment was established in French as the foundation of the Beaux Arts.

The Beaux-Arts Style

The 17th century was the starting point for establishing private and independent schools and academies such as the Franciscan Literature Academy (literary Académie française) in 1635 by Cardinal Richelieu (1585-1642) for the French Language, the Academy of Sculpture and Painting (Académie de sculpture et de peinture) by Cardinal Jules Mazarin (1602-1661) in 1648, and the Academy of Sculpture (Académie de sculpture) and School of Architecture (Académie d'Architecture) by the king Louis XIV (1638-1715) in 1671 in Paris (Pedersen, 1996). The academy was designed based on the private offices of great architects who came from noble families. The first director of the academy Nicolas-François Blondel (1618-1686) also was an engineer and architect who believed in classical design and rationalism in the construction of buildings (Vuillemin, 2008). The Academy missioned to train the students based on the monarchy, hierarchy, and aristocracy structure (Griffin, 2022).

Two movements were effective in the discontinuity of the Academy of Architecture in France. First, the Great Revolution of France 1789-1799 that changed all social and political thoughts. Second, the Enlightenment movement was transcribed to an atheist idea among the general public that had the consequences to a new movement in thought in terms of God as a metaphysics (Griffin, 2022). French Great Revolution ended the Academy and after some years of fluctuation, Ecole des Beaux Arts was born in 1819 through the integration of three art schools including sculpture, painting, and architecture (Griffin, 2022). The Ecole Beaux Art was a revolutionary movement to respond to the philosophical and political streamlines in France and Europe at that time (LDCRT, 2024). While, the motto of the Renaissance architecture was the "ideal city" and "harmonic architecture" (Merriman, 2010, p. 62), however, Beaux-Arts, Paris innovated an ideal form for buildings design which was celebrated for many years in Europe and North America (Sennott, 2004). Two great philosophers were so effective to form new ideas that could be applicable in the new generation of schools in Europe importantly Emmanuel Kant (1724-1804) with transcendental idealism and consciousness, and Johann Fichte (1762-1814) with the philosophy of psychology. These two foundations formed the German Idealism that generated idealism and romanticism in Europe and the world in the 19th century.

Program structure and design studios

The Beaux Art style in education was concentrated on ateliers (design studios) which were the location of the major part of education including painting, sculpture, art, and architecture. The photographs showed that the drawing desks were common and shared in Beaux Art ateliers. The students had individual tools such as drawing boards and tools (Verat, 2022). All the activities took place in an atelier as a common place with different students to work in the mornings for the preparation of drawings on a well-known project and in the afternoons, the comments of the patron (the master) of the atelier. Students in the Beaux Art worked from 8 am to 9 pm in the atelier with a short time for lunch six days per week (Cunningham, 1980). The tasks of the students included two important sections first, theoretical courses through lectures and drawing tasks in the morning, and critiques and evaluation by the patron (the master of the studio) in the afternoons. The key aspects in both activities were the application of sketches (esquisse) as the process of assimilation of knowledge by the students (Laroche, 2008). This assimilation of knowledge through sketches enhanced the abilities of the students in drawing through different courses in drawing, painting, and sculpture (Garric, 2017). For a long time, the Beaux Art did not include an academic structure (Griffin, 2022). The Beaux Art educational structure was contracted based on weekly lectures, public lectures, drawings, examinations, and critiques. The Beaux Art did not follow systematic courses or module-credit structure but rather encouraged the atelier activities, competition in design, and critics. The pedagogy in the Beaux Art was constructed in three portions basic drawing elements, sketches (esquisse), and design competition (Garric, 2017). The main academic ideology of the Beaux Art was a trinity that started from Vitruvius' ideas on architectural specifications. So, ateliers encompassed three instructors with different responsibilities including tutor for beginner students, competitors, and the selector of the students for the competition. This style was inherited by new generations of instructors who were former students in Beaux Art (Cunningham, 1980).

Garric (2017) highlighted that the main critique of the Beaux Art was based on the application of the romanticism style to arrange juries for the competition coming from painting, sculpture, and architecture fields rather than construction and engineering. This critique was first exposed by Viollet le Duc (1814-1879) former instructor of the Beaux Art who left the Ecole and joined to Polytechnique of Paris (Laroche, 2008). The Beaux Art style of teaching, running of ateliers, and competition changed over the years in the 19th and the 20th centuries. However, the students played important roles in inviting the architects, tutors, and juries to the school and final projects. Garric (2017) exposed that the Beaux Art was the most liberal school of architecture in the mid-19th century and the studios were run by the students to facilitate free speech and design. Despite the structure of the Academy based on the aristocrats and noble people in the early stage of the academy, the French Revolution resulted in to open the door for the bureaucrats, bourgeois, and middle class people (Crosland, 1992; Roche, 2000).

Epistemological knowledge

Cunningham (1980) mentioned that the Beaux Art ateliers were arranged to select the best students through different examinations and exercises. The examination was a main process to filter the students in different stages. The talented students should proceed and other students should stay in the level (Draper, 1977). This style of filtering the students for learning process was rooted in Kantian idealism and prior philosophers' ideas about the ultimate purpose of everything (Van de Vijver & Mathijssen, 2024) that was the predominate philosophical approach in 17th and 18th centuries and resulted in the establishment of the first school of architecture. The Kantian theory was constructed on fundamental reasons for the all actions we do in terms of self-development and practices (Maskivker, 2014). The structure of the education in the Beaux Art was designed based on differentiation between the students as talented or gifted students and normal who should be eliminated through serious and systematic competitions and examinations (Draper, 1977; Drexler, 1975).

The students followed the instructions of the patron to fulfill the tasks in design studio. Theoretical courses were free speech by famous instructors, architects, or artists. The source of knowledge was provided by visiting the great buildings, redrawing, sketching, examination, and critiques to assimilate knowledge in the minds and hands of the students (Carlhian, 1979). Despite Vitruvius's suggestions about educating architects through supplementary topics such as philosophy, music, poetry, and astrology, many educational institutes did not follow the suggestions. One of the main reasons was the relationships between architecture education and architecture practices that education follows the practices (Draper, 1977; Garric, 2017).

Transformation of knowledge in the Beaux Art was designed based on the learning history of architecture through redrawing of the monuments and great masterpieces of architecture projects particularly from Rome (MOMA, 1976). While the study of the students was limited to individual projects in Rome, in the early of 20th century, there was another perspective to study the entire city (Garric, 2017). Looking to the teaching structure and applied knowledge identify that the Beaux Art passed three philosophical approaches during the time including rationalism, idealism, and romanticism.

Philosophical foundations of Beaux Art

Neoclassicism as the sign of rationalism

Neoclassicism was the main objective of the Academy of Architecture in the earlier period of establishment in the late 17th century. Despite the speech of Blondel (Griffin, 2022, p. 1) to recommend survey classicism to be used for the "monarchic and civic buildings", the Great French Revolution changed the mission of the Academy. After the revolution, the Academy was restructured with the name of the Beaux Arts in the line with neoclassic style that should be celebrated by the architects, instructors, and students. It was based on the Enlightenment achievements grounded on the mathematics and science which predominated over all aspects of thoughts and activities based on rationalism.

Neoclassicism was the reaction of the art movement to the Enlightenment era in terms of the 'era of wisdom' (OER, 2024). This movement in art and architecture vitalized the classical ideas to put human figures, size, and form as the central elements of expression, illustration, and representation. In architecture, it referred to the celebration of Greek and Roman proportions, principles, and forms in building design (Jones, 2015). The main mission of this style was to show the authority of science and empirical activities over the power of the church, imperial oligarchy, and aristocracy in the manifestation of buildings such as to push back Rocco, Baroque, and Gothic styles that represented aristocrat, monarchy, and church powers, respectively. New classicism encouraged geometric, symmetric, harmony, and balance as the key principles in design based on mathematical perspectives. The main philosophical reason beyond the neoclassicism was to advocate a continuation between classicism and neoclassicism to deny the historical gaps particularly, the Dark and Middle Ages, based on the achievement of the Renaissance and Enlightenment.

Rationalism and its physical product in terms of neoclassicism resulted in a set of great buildings and architects across the world in the 18th and 19th centuries such as Claude Nicolas Ledoux (1736-1806) with Château de Mauperthuis, Jacques-Germain Soufflot (1713-1780) with The Panthéon, Paris, Jean-François-Thérèse Chalgrin (1739-1811) with Arc de Triomphe, Louis-Pierre Baltard (1764-1846) with Palais de justice historique de Lyon, and many other architects and projects (Craven, 2019; Drexler, 1975; Garric, 2017). However, rationalism faced a new fundamental counterpart as idealism with Kant, Fichte, and Schelling (1772-1829) to form German Idealism (Tafahomi, 2023).

Idealism as critiques on the Enlightenment

The Enlightenment did not continue in many countries as it started. Germany was the location of the criticizing the Enlightenment philosophy which resulted in German Idealism. Ameriks (2006a) exposed that the German Idealism was a cultural movement rather than a philosophical school of thought. Kant was the key figure to start the idealism in the 18th century by criticizing Descartes' philosophy (Fleischacker, 2013). Kant's ideas were constructed based on sets of critiques on the predecessors' philosophies who formed the Enlightenment as rationalism and reasoning. Through the critiques, Kant formed a new form of metaphysics grounded on the knowing, perception, and understanding in terms of transcendental idealism (Baur & Dahlstrom, 1999). Successors philosophers developed

German idealism such as Fichte with subjectivity, consciousness, and intellectual intuition, Schelling with non-mechanistic aspect of nature, and Hegel with dialectical history and aesthetics (Ameriks, 2006b; Dunham et al., 2011).

The main ideas of German idealism were embedded in the role of humans to understand, perceive, and interpret reality. Despite the emphases of the Enlightenment movement on the objectivity of science and knowledge from the subject, German idealism criticized the objectivity of the subject and believed in the important role of the subject to form the consciousness. For Kant, the reality of materials was dependent on the perception of the people about the materials. He criticized pure reason and practical reason through hypothetic ideas on the existence of other aspects of knowledge in the mind, perception, and experience of people (Holzhey & Mudroch, 2005; Thorpe, 2015). Kant also in answering questions about the Enlightenment criticized the unpublicized results of the Enlightenment among the general public (Kant, (1999) [1784]). The critique on pour reason was recognized as the main engine of Romanticism movement. The romanticism started by Goethe (Johann Goethe 1749-1832) and his works in Europe (Regier, 2016).

Romanticism and Beaux Art Style

Romanticism was also described as the “counter-enlightenment” movement in Europe (Regier, 2016, p. 170). Despite the extreme sense in the definition, romanticism in Europe was a reaction to the mathematical and rationalized form of thinking. Many factors were counted in terms of the roots of romanticism such as the French Revolution, Fichte’s philosophy, and Goethe’s novels (Warman, 2016). Fichte developed the Kantian ideas based on effective factors in perception such as intuition, emotion, and insight into both objects and subjects rather than rationalism. This style in art and literature refers to storytelling from the perspective of the users in daily life. The characters of romanticism in art and literature were selected by the authors from the ordinary people who engaged in extraordinary conditions to discover the right things to do which was called by Friedrich Schiller (1759-1805) in terms of ‘purification of the soul’ (Guyer, 2006). The Sturm und Drang (storm and stress) musical play in 1760, Faust by Goethe in 1790, and Quasimodo by Hugo in 1831 were the characteristic streamlines of romanticism in the literature in Europe that connected the romantic art to romanticism architecture in the Beaux Art.

While rationalism and neoclassicism were the starting point of the academy and then Ecole des Beaux Art (Griffin, 2022), Kantian theories, revolutions in the world and France, and the romanticism movement transformed the Beaux Art style from neoclassicism to own special style as a selection of neoclassicism, classism, Baroque, Rocco, and Gothic under the atmosphere of romanticism. The Beaux Art style was formed based on the intuition, emotions, individualism, and meaning-ability of beauty in a wide culture. The common character of the Beaux-Arts style with the inspiration from romanticism was constructed based on symmetrical rhythms, distinctive ground and skylines, roof form, arched façades with windows, sets of windows and balconies, decorative balustrades on facades, minimalistic decorative elements from renaissance styles such as sculptures, motives, and decorative garlands, in eclecticism forms and scales. The fine examples of the Beaux Art style of design were the National School of Fine Arts (l’Écolenationale supérieure des Beaux-Arts) and then Beaux-Arts Architecture by Alexandre Lenoir (1761-1839), François Debret (1777-1850), Félix Duban (1797-1872) constructed 1830-1863, Palais de Justice, Paris by Joseph-Louis Duc (1802-1879) constructed 1847-1871, Paris Renovation Project by Georges-Eugène Haussmann (1809-1891) and the sets of Parisian apartments constructed 1854-1870, and the Royal Museum for Central Africa by Charles Girault (1851-1932) constructed 1904-1910. In 1850 the idea of the ideal city was emerged through a romantic approach to the future living style of inhabitants (Mumford, 2018). Sennott (2004) mentioned that in the Beaux-arts there were critiques of the artistic way of designing buildings rather than mathematical logic. While the Beaux Art kept its style for many years; however, it resulted in many student's movements (Littmann, 2000; Madanovic, 2018) to force universities to change the Beaux Art style. The study suggested that from 1929 there was another movement in the school that referred to a more modern style of design rather than Beaux Art style (Griffin, 2022).

Polytechnics Style

European academic approach historically was divided into a dichotomy approach to classify knowledge in terms of Liberates Arts (artes liberates) and Mechanical Art (artes mechanicae) in Middle-Age era (Ruegg, 1992). In this classification, sciences were related to the earth, and nature was categorized as mechanical knowledge. However, other fields such as philosophy, laws, and art were sorted as liberates knowledge that the term of liberates was referred to the metaphysical aspects of those fields. Even medicines and architecture were classified in the liberates arts in the first classification in the 15th and 16th centuries. This classification continued in the Renaissance, Enlightenment, and the early stages of the modern era.

Evidence showed that the technical schools were established by militaries to teach technical topics such as architecture, engineering, artillery, and hydraulics to the students. For example, the Court Academy in Spain in 1583 was one of the fine examples to governmentalize and militarize the educational processes (Simone, 1996). Such kind of activities also took place in other places such as Northern Italy where the religion, law, art, and physicians field of studies were divided into specialized schools with the order of Victor Amadeus II (1675-1730) in 1719 (Frijhoff, 1996a). Pedersen (1996) made a list of the first polytechnic movements by governments in Europe to create disciplinary technical centers for military purposes in the 17th century such as Prague in 1717, Hungary 1735, France (Ecole des Ponts et Chaussées) in 1744, Freiberg in 1775, Vienna in 1776, Hanover in 1778, and Copenhagen in 1778.

The major part of the technical schools in Europe were designed either to introduce the students to the fundamental courses in science such as mathematics, chemistry, and physics as a foundation and then a new registration for professional schools such as medicines and engineering. For example, the Ecole Polytechnique of Paris was founded in 1794 "to provide basic knowledge for the further studies in more specialized Ecole'(s). The architecture course in this structure was arranged under geometry including "stereometry, architecture and fortification" (Bockstaele, 2004, p. 496). Guagnini (2004, p. 596) revealed the technical schools in Europe were a demand from militaries to train the students as future state officers in some technical fields such as "Ecole du Genie Militaire at Mezieres(from 1775, the Ecole Royale)" and "Ecole de l'Artillerie et du Genie Militaire in 1802. This training process by the technical schools was celebrated by industries and the number of the students for registration in those schools was increased. A high level of demand for technical schools resulted in tensions between the technical schools and universities at the end of the 18th century and the whole 19th century. Nonetheless, with the pressure of the central and local governments and the new orientation toward research in natural science, many technical fields were adopted in universities. This new movement resulted in new waves of war or potential of war based on the educated military officers in Europe and accelerating the establishment of Polytechnique (s) in other regions.

Program structure and design studios

The main question raised by the technical institution was whether to train or to teach the students (Stewart, 1992). Bockstaele (2004, p. 496) analyzed the Polytechnique educational structure and highlighted that for the first time curriculum of Polytechnique recommended the general and specific aspects of knowledge such as general mathematics and applied mathematics in geometry and mechanics, general physics, and experimental physics. Nonetheless, all courses were fundamental based on the military and industry needs to lead the students for higher Ecole (ecoles d'application) such as "the Ecole de Medecine, the Ecole des Arts et Metiers, Ecole d'Artillerie, the Ecole du Genie militaire in Metz, the Ecole des ponts et Chaussees, or the Ecole des Ingenieurs de Vaissaux".

Ecole Polytechnique had a more construction-oriented architecture program than design as the Beaux Art. Polytechnique was a criticism on the Beaux Art style of education (Garric, 2017). Polytechnic movement was rooted in the similarity between construction and architectural activities. There is a quotation from Jean-Baptiste Rondolet (1743-1829) who argued that architecture is construction not art (Sennott, 2004). Lean Nicolas Louis Durand (1760-1834) as the first pioneer to create modular systems for building industrialization and modern architecture was a professor in Ecole Polytechnique (Sennott, 2004). The Polytechnique with the selection of some special courses to teach made a differentiation between Newtonian science and the other field of knowledge

The education in technology in Britain was more fitted on the apprenticeship activities for engineers who should work in constructions, railways, water channels, and mining. The courses were divided into different topics and projects that should be fulfilled by the students such as mathematics, mechanic, physics, engineering, drawing, astronomy, fortification, and practical activities (Frijhoff, 1996a; Guagnini, 2004). The Ecole (s) was normally led by mathematicians or engineers such as Gaspard Monge (1746–1818) a key figure of Ecole in the early 19th century. This technological perspective was the mainstream of Ecole, which some of the rationalist instructors who left or were pushed to quite from the Beaux Art, joined the Ecole Polytechnique due to the beliefs, ideology, and teaching styles such as Viollet le Duc (1814-1879) (Laroche, 2008, p. 12). Laroche advocated the main differentiation between Beaux Art and the Polytechnique was in the application of technology.

Epistemological knowledge

The Ecole Polytechnique (s) had a significant role in the modernization of France and European countries based on the industrialization model of development (Guagnini, 2004). The technical instructions such as Polytechnique (s) emphasized the training and practical activities in a special field due to the needs of the industries in specific locations. So the Polytechnique was well fitted to the context and market needs. They started with a basic program which was claimed by the industries and then upgraded to more developed forms.

Courses in Polytechnique (s) included three years of fundamental education and training in both theoretical and practical subjects to make ready the students for an advanced 2 years education in specialist Polytechnique (s) (Guagnini, 2004). This style of Polytechnique was vitalized by the Bologna agreement in 1994 to reorient architecture education in Europe (EEA, 1999). The new generations of the Polytechnique (s) were influenced by the Ecole Polytechnique of Paris which advocated the educational system of pupils as a "discipline". Guaginin (2004, p. 605) described the discipline in terms of the "strict and well-established rules that had their roots within the engineering community" through "apprenticeships" in a "hierarchical system" based on "experience" of experts at that time. In the middle of the 19th century, the curriculum of the Ecole Polytechnique Paris in terms of the discipline was adapted to the major Polytechnique (s) in Europe such as Prague and Vienna (Polytechnisches Landesinstitut of Prague, the Polytechnisches Institut of Vienna) in 1806 and 1815, respectively.

Napoleon supported the Ecole Polytechnique as the most "prestige center" for education in 1804 in France and it made the polytechnic a leading model of education in France and Europe (Guagnini, 2004, p. 600). Many of the foreign students participated in Ecole Polytechnique between 1800 to 1850 (Bockstaele, 2004). Even, the legitimacy and popularity of mathematics and physics were so high that civil engineering and architecture programs were under subdivision of physics departments such as the University of Vilnius. However, Guagnini (2004) claimed that the general trend in Europe kept civil engineering, architecture, and artillery under technology subjects in the hand of Ecole (s) of the military. This structure referred to the Newtonian rationalism, empiricism, and functionalism ideas in the design process.

Philosophical foundations of Polytechnique (s)

Newtonian ideas and mechanical rationalism

Isaac Newton (1642-1726) advocated the principles in science, philosophy, and nature through mathematics through different publications. His great work concentrated on developing, approving, and clarifying the predecessors such as Nicolaus Copernicus (1473-1543), Johannes Kepler (1571-1630), and Galileo Galilei (1564-1642) (Edelglass et al., 1991) theories in astronomy, mechanic, and mathematics. The Newtonian ideas were constructed based on the natural laws that exist in nature that could be explained through mechanics, mathematics, and physics. Those laws constructed permeant and consistent relationships that was called as principles. Newtonian ideas followed the matter section of the Cartesian ideas by Descartes based on a trinity of matter, mind, and god. In Newtonian ideas, all phenomena should be reduced into the exact matter to be observed, tested, and defined through mechanics and mathematical physics. For him, mind and god were in the field of theology and metaphysics discipline.

Matters are the central point to analyze in Newtonian ideas through science, particularly the mathematical explanation. It resulted in establishment of mathematical courses in Polytechnique (s) to train students. The mechanical and mathematical explanations were related to industry, nature, and science. This structure formed the common courses in Polytechnique such as mathematics, physics, chemistry, mechanics, and geometry. The architecture courses were also translated through mathematical relations and the laws and disciplines to follow. Newtonian approach to make laws for physical elements was resulted to the fundamental and advanced principles, disciplines, and laws (Guagnini, 2004) that should be applied in design and construction in architecture program.

Empiricism

The empiricism was a result of the Enlightenment achievements to focus on the empirical evidence particularly Descartes and Hume. Hume emphasized deductive reasoning in science and philosophy. He argued that inductive reasoning creates a circular explanation rather than exact fact, evidence, and matter. Therefore, all the aspects of knowledge and science should be reduced to a deductive scale to be tested through the methods. A new generation of the Polytechnique based on the request of militaries and industries reoriented the curriculum based on related courses to empiricism.

The evidence showed (Long, 2017) that there was an interconnection between the architects, architectural projects, and education in architecture. The experimental activities in the educational center particularly in Polytechnique (s) were common through different classes and subjects in the curricula. While Blondel started this style in the Academy, however, the experimental tests on the technology, materials, and systems were developed mainly by Viollet-le-Duc the characteristic instructor of Polytechnique who was a former instructor in Beaux Art (Bressani, 2017). Empirical activities not only were a new trend in the educational undertaking but also were encouraged by industries in the context of the industrialization movement in 18th and 19 centuries.

Functionalism

Functionality was one of the key pillars in Vitruvian theory to define the architecture. Vitruvius categorized three fundamental prerequisites for architectural products including "firmita, utilitas, and venustas" (Jones, 1981, p. 68) in terms of construction, function, and aesthetics that were also rephrased in terms of firmness, commodity, and delight (Proudfoot, 2000). The functionality specification of buildings based on the

Vitruvian theory was one of the elements that supported the Renaissance architecture to rebirth the Greek and Roman styles which many documents showed such respectfulness to the function of the buildings by the Renaissance architects in their design (Marder, 2017).

Functionalism was theorized in the 19th century in science and advocated in all fields of knowledge even in metaphysics. In the architecture schools, Viollet-le-Duc was the key person to emphasize the functionality of the buildings. Even, there is a hypothesis that the term of function in architecture first was seeded by Viollet-le-Duc, not by the modern architectural movement in the 20th century (Bressani, 2017). Louis Sullivan (1856-1924) in his study time in the Beaux Art in 1875 learned the theories of Viollet-le-Duc in both Beaux Art and Polytechnique. Nonetheless, Bressani (2017) claimed that many of the restoration projects by Viollet-le-Duc were more decorative than just functional. In this regard, the functionality of a building in that time was more referred to the technological aspects rather than the programming of the building (Tafahomi, 2022b). New technologies and materials advocated by the Polytechnique instructors particularly metal and glass due to the connection with industries. New materials and technologies were symbols of modernism and Europe celebrated this trend based on the Enlightenment achievements.

In detail, some exhibitions were so important to form the modernism entitling and distinguishing. It started with the Crystal Palace Great Exhibition in Hyde Park in 1951 which was a new approach to applying metal and glass in a wide range of forms, sizes, and scales. The designer was a gardener and botanist who learned design activities through apprenticeship and practices in the UK. While the main reason behind the design of the Crystal Palace was a large greenhouse for the colonial species, the building itself was a manifesto to challenge the knowledge of architecture, engineering, and design in Europe. A set of exhibitions took place in Europe to demonstrate such progress such as the Ireland Exhibition in 1853, the Munich Exhibition in 1854, and the Paris Exposition in 1855. Those exhibitions with a great number of visitors illustrated the power of iron, glass, and technology on the new generation of buildings, architects, institutions such as Polytechnique, and technological universities.

Bauhaus Style

Private schools of architecture were a movement in modern times based on freedom from governments, authorities, and ideologies. For example, AA (Architectural Association) and RIBA (Royal Institute of British Architects) were established in the middle of the 19th century in the UK to lead the architecture practice and education out of the government structure. It was a starting point for the private and semi-private schools of architecture. Bauhaus in short and interrupted life opened a new perspective for the art, craft, architecture, and design in the modern time of Europe and then in the world. Berman (1988) pointed out that Bauhaus was a reaction to the results of WWI (World War One) in terms of modern style of design, crucial point of view to history, and industrial mass production. However, in the four volumes of the history of the universities in Europe, there is no name of Bauhaus. It seems this school of design and architecture did not exist in the history of the universities and higher education in Europe.

Bauhaus was established in 1919 after WWI in the Weimar Republic by merging two previous schools the “Academy of Fine Art” established in 1903, and the “Weimar Art and Craft Institute” (Curtis, 1982, p. 119). Bauhaus (Building-House) was a new term to show the objective of the new school in German language. Walter Gropius (1883-1969) was recommended as the new director of the institution to shape the school. The main idea in the new curriculum was integration between art, architecture, and craft activities with the support of Johannes Itten (1888-1967) Swiss expressionist painter. All studios were shifted from atelier-based to craft-based workshops. The motto of the school was constructed based on the “no distinction between artist and craftsmen” (Frampton, 1992, p. 123). The study suggested that Bauhaus was influenced by the

British Art and Graft movement and the Munich Blue Rider style as a German expressionist led by Wassily Kandinsky (1888-1944) at that time. The first location of Bauhaus was in Weimar in 1919 until 1924. Then it was relocated to Dessau based on some political and financial issues. Despite no evidence of the Marxist idea in the Gropius publications, however, his speeches and the curriculum of Bauhaus referred to some level of sympathy and appreciation of the labor workers (Frampton, 1992). In addition, the second director of Bauhaus was a member of the socialist party in the country (1925-1930) and there were many collaborations with the Vkhutemas (Higher Artistic and Technical Workshops in the Soviet Union) movement that resulted in a new method of education as teamwork between tutors and students rather than up-down method (Adaskina, 1992; Bokov, 2021; Tafahomi, 2023). The third director of Bauhaus was Mies Van der Rohe who shifted the location of Bauhaus to Berlin (1930-1933). Bauhaus was disbanded by the pressure of the Nazi party in 1933. Despite the short life of Bauhaus for 14 years, Bryant (2004, p. 73) exposed that Bauhaus was the ultimate symbol of modernism for the change of the society through " a new social order through a new art" and consequently architecture which manifested by Gropius in 1919. While Bauhaus advocated an "apolitical socialism" based on "brotherhood manners" rather than a political orientation (Curtis, 1982, p. 119), however, the style of working in Bauhaus reflected a traditional working style similar to the medieval era based on the masonry and apprenticeship activities.

All Bauhaus architect-instructor had Polytechnique backgrounds or masonry experiences such as Walter Gropius at the Technical Universities of Munich and Berlin, Adolf Loos (1870-1933) at Dresden University of Technology, Adolf Meyer (1881-1929) in Kunstgewerbeschule (Applied Art) Cologne and Düsseldorf (Bauhaus, 2024), Hans Wittwer (1894-1952) in ETH Zurich, Hannes Meyer (1889-1954) through apprentice activities, Mies van der Rohe (1886-1969) through apprentice activities under supervision of Peter Behrens (1868-1940) who was an artist, architect, and craftsmen. Behrens's office inspired Gropius, Meyer, Rohe, and even Le Corbusier to be part of the art and craft movement when all of them worked in the office of Behrens in Berlin.

Program structure and design studios

The basic design course was an innovation by Bauhaus to introduce the students to the purpose-based design style through a combination of art, craft, and design. The materials, textures, fabrics, and colors were applied based on principles of design such as proportion, rhythm, and contrast (Cross, 1983). The basic design was presented by Itten in the first three years of the school, however, with Moholy-Nagy (1895-1946) the Hungarian designer the course shifted to more practical activities for products rather than theories of art (Curtis, 1982). Frampton (1992) mentioned that the main differentiation between the ideas of Itten and Moholy-Nagy in education was located in the spiritual and metaphysical foundations of Itten's ideas to teach art to the students.

According to the diagram of Bauhaus's curriculum (Getty, 2024), the program in Bauhaus included 4 to 5 years of studies in different levels and topics. The students started with preliminary courses in basic form, design, and workshops to learn drawing and design methods and techniques including proportions, color, shapes, forms, and compositions. The successful students participated in some progressive courses such as composition, natural and materials-tools, fabrics-colors, and construction studies. With this knowledge, the students participated in workshops such as metal, clay, stone, glass, color, wood, and fabric (texture). Those workshops provided experiments and knowledge to apply in buildings and construction which was the ultimate objective of Bauhaus. The final year was related to the specialized course in architecture, product design, or industrial design. This curriculum appeared in the motto of Gropius in terms of no differentiation between art and craft based on the art and craft movement at that time.

Hannes Meyer, the second director of Bauhaus established specialized departments such as architecture in 1927 in Dessau (Bauhaus, 2024). Some of the courses added to the curriculum of Bauhaus such as philosophy, psychology, sociology, and photography were added into discussion and courses. Frampton (1992, p. 126) mentioned that the pedagogy of the Bauhaus was designed based on working with machines for "mass productions". Constructivist, expressionist, and suprematist approaches were celebrated by Bauhaus. The students started with a simple problem and mechanical machines and gradually the problem and machine became complicated. It was so similar to the factory structure of production. For this reason, Bauhaus made contracts with industry for the productions. The problem solving constructed a process of research in workshops by the students (Mindrup, 2014).

Epistemological knowledge

Cross (1983) attempted to draw a line between John Dewey's (1859-1952) pragmatic theories and Bauhaus's educational structure in terms of philosophical background. However, Fallace (2017) revealed that the atmosphere of education in the US was polluted with anti-German ideas that there were appeared in work of Dewey. The common ground for education in Germany and the US was German Idealism particularly Herbartians' philosophy (Johann Friedrich Herbart 1776-1841) and some aspects of Hegelian and Marxism thoughts based on the values of the educational centers to shape a new society. Nonetheless, the root of the pre-pragmatic approach in the Bauhaus should be investigated in the apprenticeship activities in the office of Behrens in terms of processes of art, craft, architecture, and design that were so effective on the structure of the Bauhaus.

This structure of the working in Behrens and Bauhaus was so close to the structure of teaching architecture in the Academy of Platonica in Florence (Frijhoff, 1996) based on apprenticeship through different practices through materials and skills that Frampton (1992, p. 126) called this style of the education in terms of "medieval" style. This style of education was internalized by some of the instructors who did not have any official architecture education background but they learned art and design through masonry, practice, and self-learning. For this reason, the workshops were the main location of training and educating of the students in the earlier stage of Bauhaus (Doyle, 2016). The study mentioned that the most achievement of Bauhaus was the equality of the students and staff to work together in workshops and product processes (Cross, 1983).

While there are many advocating left-wing movements in Bauhaus, evidence of sympathy between the staff and the Marxist ideas in the Soviet Union, and collaborations with the Vkhutemas movement, however, the main objective and mission of the Bauhaus was to teach the students through self-experience and doing in the real context of the society. This process was more close to the German Idealism theories such as Fichte, Herbert, and Hegel rather than Marxist-Leninist theories for education.

Two factors were so significant in the shaping of the philosophy of education in Bauhaus. First, Behrens's office influenced deeply of his apprentices to see architecture not only building but also a process of the production and industrialization of materials, and product design. Second, working as construction workers, masons, and draftsmen in different offices and projects framed their ideas to apply craft as the main medium to design projects. There were three contextual and effective ideas that shaped Bauhaus philosophy for education including socialism and Marxism, modernism, and constructivism movements.

Philosophical foundations of Bauhaus
Sociology and Marxism

Europe and France were centers of the social and particularly urban movements between the 18th to the 20th centuries. Four times revolutions, three republics, three empires between 1789 to 1871, other revolutions in the world such as Haiti and the United State, renovation of the Paris by Hussmann made the social issues on the top list of requests by the general public and political activists such as Hegel, Auguste Comte (1798-1857), Proudhon (1809-1865), Marx (1818-1883), and Engels (1820-1895) through different research and publications (Tafahomi, 2023). The social theories were formulated by Comte under the supervision of Saint-Simon (1760-1825) who was an important activist in the French Revolution. Comte advocated the term sociology in mathematical and experimental ways to study human life in a sociological context he formulated it in terms of positivism. In addition, Engels published a book about the working class conditions in England in 1845 as the first systematic research about the working class, and three years later Marx and Engels published the Communist Manifesto in 1848 to expose the condition of the laborers after the industrial revolution (Royce, 2015).

Due to increasing the population of cities based on industrialization and social diversities architecture arrived at the central point to deal with social problems. Some new approaches to urban planning and industrial cities were introduced by Arturo Soria y Mata (1844-1920) an engineer, Ebenezer Howard (1850-1928) a journalist, Tony Garnier (1869-1948) and Eugène Alfred Hénard (1849- 1923) architects (Mumford, 2018) that referred to the imagination about by-pass, garden, and monumental cities, respectively (Hall, 2014). In the late of the 19th century the first movement for affordable and social housing took place in Europe and the US through the investment of municipalities such as London and Manchester in England and industrial companies such as Pullman in the US. This process of paying attention to social aspects of the design resulted in thinking about the process of architectural design in terms of social context and people needs. Frisby (2004) highlighted that without social, political, and economic changes cannot imagine modernism in the world. Under advocating of the social equality, Bauhaus moved toward standardization of design to generalize the results to everywhere in terms of international style. The standardization was rooted in the Polytechnique-biological approach and the social theory of the similarity of human needs (Whitford, 1981). In addition, the Constructivist art, Suprematism, De Stijl styles also were a reaction to the social and political norms to present an alternative art and point of view to the world which applied in Bauhaus as a grounded style.

Modernism

Modernism is a label to covers all changes between the 18th to the 20th centuries as a result of the Enlightenment. Despite a variety of definitions in literature, modernism was a clear result of the Enlightenment era. Studies on the achievements of the Renaissance and Enlightenment movements listed 5 important accomplishments including 1) empiricism to examine all observations, 2) rationalism to apply methods, 3) skepticism to question beliefs, 4) liberalism to respect individuals, 5) human rights to establish common laws (Dupre, 2004; Fleischacker, 2013; Schmidt, 1996; Tafahomi, 2023). Those achievements resulted in to institutionalize academic center in Europe and other countries. Both institutionalization and industrialization paved the way for modern society. Lavey (1996) in the definition of modernism referred to a ‘difference’ in any aspect of the previous style of beliefs, life, and actions with the new one. This differentiation from the past was the key essence of modernism. Berman (1988) advocated modernism with a sentence from the Communist Manifesto “All that is solid melts into air”. He implied the role of Marxism in publicizing modernist ideals in the world through experiences in different societies and contexts. Industrialization, rationalism, liberalism, and secularism constructed modernism to give room for the individuals.

The modernism process was not expanded in a similar way in all societies, and there were sets of differentiation between the social space and physical spaces in the modernity expressions (Frisby, 2004). Nonetheless, modernity referred to modern social relationships that before did not exist. Particularly, the White and Red revolutions in Russia as ideological change, the WWI (World War I) as political change, rising powers for women and labor in cities as social change were some elements shaped modern thinking in the 20th century to form modern architecture (Berman, 1988; Whyte, 2004) as context of Bauhaus for education. This context also generated a great cluster of architects who formed particular styles in architecture in terms of modernism such as Frank Lloyd Wright (1867-1959) with organic theory, Le Corbusier (1887-1965) with machine theory, Walter Gropius (1983-1969) with international idea, Mies van der Rohe (1886-1969) with glass cube, Erich Mendelsohn (1887-1953) with utilities idea which all of them graduated from Polytechnique institutes although some of them took the title as Technology.

Constructivism theory in art and Architecture

Constructivist theories had rooted in the Art and Cart, Art Nouveau, and school Vkhutemas movements as the manifesto of modern time for art, design, and architecture. Harvard (2013) exposed that the foundation of the art and craft movement was rooted in social movement in the late 19th and earlier times of the 20th century. The art and Craft movement and the Art Nouveau style were a parallel movement to represent modern art in the century although there are some disagreements on this interlocking concept. While the art and craft rejected historicism in general, however, they applied art, aesthetics, and geometric principles in designing things and goods for market and decorations. The movements were a reaction to the mass production and industrialization of art decoration, and design. They started in the 19th century to criticize the low quality of the applied art and design to produce goods for markets. They believed in the quality and artistic aspects of the design to improve the visual and perceptual qualities for people in their social context.

While the movements were effective in the Bauhaus; however, many artists such as Moholy-Nagy, Paul Klee, and Wassily Kandinsky, Piet Mondrian transformed all art styles in Bauhaus and constructed their special style of design based on the constructivist social theory of art. The applied art in a modern time was the main objective of the movements although art and craft movement was related to pragmatic theory (Fallace, 2017). Drexler (1975) mentioned craft was an initial orientation by Bauhaus to produce craft students to be part of the modernism movement. This movement was based on a geometric design that fitted well with industrialization and machinery activities. Nonetheless, all movements in the Bauhaus transformed into a modern style of art and design that was fundamentally different from the original styles to advocate a modern style of design for a modern society.

Conclusion

The Beaux Art School in Paris faced three times transformations (one source referred to four times) based on rationalism, idealism, and romanticism to respond to contextual demands for the neoclassic, national, and innovative styles. Despite the emphasis on the construction techniques in the earlier years of the Beaux Art, after the Great Revolution and other political instability, the Beaux Art shifted to the more artistic aspects of the design through the celebration of the great architectural project in Rome and some innovation to contextualize for France. The Beaux Art style was regenerated by other architects across the world through the unique style of the design of the building. This style was constructed based on the bureaucratic perspective to show development, power, beauty, and glory through architectural projects. Artistic aspects of the design were the core value of design and the school and patrons celebrated this style. Knowledge of the students was formed based on patron-oriented atelier activities through lectures, drawings, and sketches based on the glory projects. This structure of knowledge was more fitted to the apprenticeship activities in private offices.

Polytechnique schools were organized by the military and governments to provide basic knowledge and skills for the students through 3 years of study in science, technology, and practices. After 3 years, the students should be spent 2 extra years in the specialized Polytechnique to be graduated in a specific discipline. The foundation of the Polytechnique was based on the industrialization process and demands for engineers, practitioners, and operators of the machines in factories. The

Polytechnique (s) constructed a system of categorization of courses based on basic, fundamental, and applied topics-modules such as mathematics, mechanics, chemistry, physics, and construction. In the architecture programs, they applied the system of education close to construction based on the innovation of building technology, function, and materials, particularly metal and glass. The system of education was constructed based on disciplines and principles in design. This discipline resulted in a modular system of construction for houses, factories, and public buildings, particularly schools and hospitals. The topic was established on the basic, fundamental, applied, and advanced that were translated into projects 1, 2, 3, and so on depending on the level of complexity of the projects. The philosophical foundation of Polytechnique was enjoyed rationalism, empiricism, and functionalism in education. The Polytechnique (s) applied teacher-center based education due to the military structure and some strict regulations on the campuses.

Bauhaus was an orientation toward the craft, labor, and socialist movements in Europe. The education in Bauhaus was drafted based on the basic design, workshops, theories, and product projects or prototypes. This process shifted the main activities from classes or ateliers to workshops for materials and sites. So, the workshops are named after topics such as metal, weaving and fabric, wood, clay, and so on. These titles also applied to architecture and construction courses such as houses, schools, and factories. The students and tutors worked together to produce final products for markets and industries. Working together created an atmosphere of equality and brotherhood in the school under socialism theories and collaborations with the Vkhutemas as a new trend in student-teacher relationships. Bauhaus improved the connection between art and craft through constructivist artists and architects to manifest modernism. The results of WWI changed all permanent ideas and put into question the social, economic, and political structures. Modernism and craft respond to the need to change lifestyle. Modernism took place as the ultimate purpose of Bauhaus to be different from the past and be modern in real time for art, design, and architecture.

Despite some similarities and many dissimilarities in those schools, this research discovered four factors that have been effective in the shaping of the educational styles in the three schools including philosophical and ontological foundation, epistemology of knowledge, architecture projects and context, and architects' belief and ideology. Figure 2 represents this relationship. An architecture school is the result of interaction between

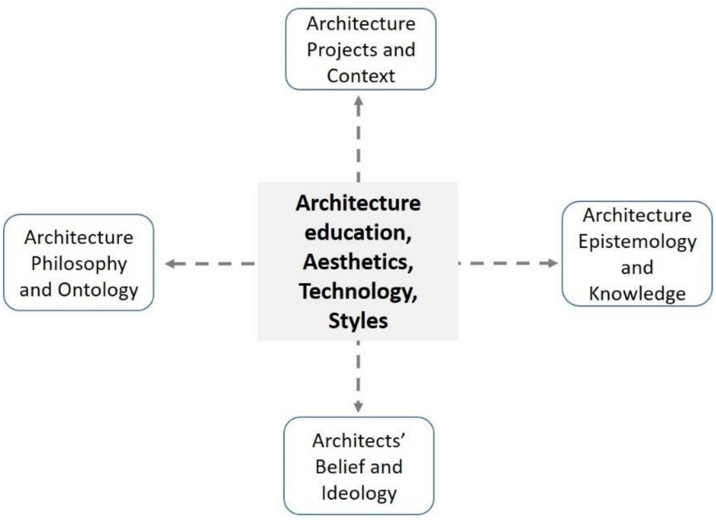

Figure 2: *the relationships between the architectural aspects*

society's ideas, beliefs, and demands that are manifested through curriculum, program structure, and activities in theoretical and practical activities. While traces of the Vitruvian components including firmness, commodity, and delight still could be recognized in architecture education, those components have been changed, transformed, or developed by time and location. Architecture education still is a hot topic to see as market-driven oriented, inner-driven oriented or social-driven oriented.

Architecture's design projects, processes, and education respond to environmental requirements, social needs, cultural beliefs, and technological progress due to time and location. Education in architecture demonstrates the philosophical foundations and methods of acquiring knowledge through the curriculum, program structure, and modules. The actions of instructors have been following some instructions based on a dictated structure, personal learning styles, or self-exploration to discover effective methods in teaching activities. The important result of this paper is to expose the relationships between philosophical thoughts and teaching activities in design studios as the manifesto of the beliefs and values. The style of teaching is a culture that is formed through every day activities by instructors. Therefore, due to the wide range of schools of architecture, the variety of educational styles refers to the differentiation in those foundations. Nonetheless, this variety creates an opportunity to expand the domains of knowledge through collaboration rather than restriction.

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Smart Materials in Green Architecture: The Role of ETFE and Phase Change Materials in Sustainable Building Design

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Abstract: Given the importance of energy in achieving environmental sustainability in green buildings, one of the most significant solutions is to reduce physical building consumption and instead use renewable energy to prevent the depletion of natural resources and environmental pollution. Utilizing advanced technologies and intelligent systems in architecture is one of the methods that can achieve energy management in buildings and ensure comfortable conditions for the occupants of green buildings.

In the field of future-oriented architecture, it is expected that in the future, materials and technologies developed over the past century will define the different challenges ahead to elevate sustainable development in the building industry. Using solar energy, one of the latest innovations in buildings, and other measures such as ETFE panels (a green roof idea with an intelligent system) and thermochromic materials, which change color to minimize heat exchange between interior and exterior spaces of the building, show that today's world faces energy crises. The use of smart materials tailored to environmental conditions can significantly impact building design and have beneficial effects in terms of compatibility with the environment, increased lifespan of materials, and the adaptability of materials to changing weather conditions, thus aiding in achieving sustainable architecture.

Therefore, this article aims to introduce intelligent materials and their applications and benefits in green building architecture based on library studies. The primary goal is to identify and highlight the most crucial aspects of using intelligent materials and their performance in buildings and how these materials behave and perform in architectural designs. The best way to leverage the benefits of these smart energy-saving materials and management for achieving sustainable architecture will be discussed.

Keywords: Green architecture, Sustainable building, Renewable energy, Phase change materials

1. Introduction

Buildings and living within them have undergone significant changes over the past two decades. It can be stated that our growing population, along with urban life, is accompanied by energy consumption and pollution resulting from human activities. Therefore, preserving the environment is one of the major factors in green architecture, making it one of the crucial architectural trends of the present era, which is addressed in economic, social, and environmental domains.

The concepts of green and sustainable emphasize compatibility with the environment and the permanence of an artificial topic, such as a building, determined by the community. Each community's persistence is supported by the current and future inhabitants. In this regard, sustainable and environmentally friendly architecture can be realized through advanced and intelligent technologies, where the most advanced models of sustainable and green buildings are placed not only against nature but also in line with environmental facilities and human comfort. A green and sustainable building aims to regulate natural conditions and control factors to optimize space utilization and comfort. This architecture endeavors to maximize the use of natural elements and renewable resources to provide comfortable environmental conditions for its inhabitants. It achieves this by employing advanced technologies and systems harmonized with natural conditions, striving for the highest efficiency in utilizing natural elements and renewable energy resources. This results in environmentally compatible and aesthetically pleasing buildings that offer comfort and environmental benefits (Liu, 2022).

Green architecture is derived from sustainable architecture, and its development has stemmed from the human need to confront the adverse consequences of today's industrial world and the consumption of the current era. The preservation and protection of the world's natural resources, prevention of air pollution, and other environmental pollutions, as well as the protection of physical and mental health, are topics that are increasingly highlighted as a global duty.

2. Green Architecture

Green design is a practical solution to problems that naturally arise before, during, and after the production process. The construction aims to minimize harmful impacts as much as possible. In addition, this practice must have a long useful life and be recyclable and reusable. Green materials should have a long lifespan and be both cost-effective and effective in combating waste and losses, making them better for reuse or recycling.

Currently, as resources are depleting and disappearing, it is time for architects, landscape architects, urban designers, engineers, and building specialists to fundamentally rethink. Specialists must base their skills and expertise on sustainable building design to support and protect the future of children and future generations in this field.

Before anything else, a green building, like any other creation, needs a creator. This means that creating a green building will help and support the individual who lives in it and its surroundings and will lead to their satisfaction and well-being. This need requires careful attention to the following issues in architecture:

Utilizing sustainable resources and focusing on the use of thermal, electrical, and lighting power, as well as daily reuse, create a union and unity that provides the building with structural stability and production. Of course, we must consider that transforming this into the essential structure of human spirit and body will result in mutual dependence and will reveal something extensive about ourselves and our rediscovery of nature. The world of nature is superior to everything else. We must enforce this design and planning because it is only in this way that progress is achieved. This fact will be successful if the group of designers and planners genuinely believe in its merits.

Often, a green building is interpreted as a building with minimal negative impacts on its surroundings. The goal of creating green buildings, based on the above-mentioned principles, is to improve water and air quality and prevent the negative effects of construction on the environment. Currently, energy conservation and the optimization of energy consumption and the use of sustainable energies play no role in the building culture of the country. Additionally, in private residential construction, particularly for the affluent classes, significant amounts are spent on excessive and inauthentic decorations, often referred to as ornamental building, at the expense of other necessary expenses. The motivation for spending these disproportionate amounts on adornment is to achieve grandeur and splendor, ultimately leading to commercial success, especially in the building and selling business. Unfortunately, this issue has become a trend in society, which is concerning.

Figure 1: *Green architecture*

The solution to the problem lies in developing new aesthetic approaches to create transformation and change in public perception and replacing the current degenerate patterns with ecological patterns based on the balance of energy conservation and optimization, and respect for the natural and social environment. This requires that architects strive to guide public taste in constructive and socially beneficial directions instead of following popular and market-driven tastes. Architects can make people believe that climatic and environmental designs are no less beautiful than the current prevalent decorations. Through architecture, society can be informed about the great economic and environmental value of energies that have become renowned for their calm and comfort. From the perspective of artists and architects, these energies can be considered beautiful above all else. The future of the world lies in the discovery of the beauty inherent in clean and life-giving energies. Let's discover the beauty hidden in clean and life-giving energies. Traditional architecture values and the environmental values of traditional architecture in many countries around the world possess significant value in the various ways of optimal use of energy and ecological exploitation of different types of energies, especially the use of sustainable and intangible energies.

The type of materials and construction techniques used in the past, especially those related to the sustainability of the building and the main load-bearing elements of the building, namely walls and roofs, or more generally, horizontal and vertical elements, naturally and automatically had a high capacity for energy storage and thermal balancing in artificial spaces compared to lightweight and low-volume materials currently in use. However, this feature by no means implies that the beauty, comfort, excellent sustainability, and environmental qualities and innovations related to the optimal use of energy in architecture are self-evident, trivial, and devoid of the need for intelligence, creative power, and science and knowledge. Contrary to detailed examination, architectural features indicate a great deal of knowledge and awareness, intelligence and cleverness, and attention to architectural details. There is a significant focus on creating comfortable and pleasant interior spaces, beauty, durability, non-destruction of the environment, and maintaining the quality of life (Vagtholm, (2023)) (Lotfabadi, (2019); Sánchez-García, 2023; Pardo, 2023).

2.1 Principles of Green Architecture

The first principle is the protection of energy, followed by the second principle, which is working with climate. The third principle focuses on reducing the use of new resources, while the fourth principle emphasizes respect for users. The fifth principle addresses respect for the site, and finally, the sixth principle highlights holism.

Green buildings are designed to meet the specific needs of their occupants, providing spaces that enhance health, satisfaction, and productivity. They ensure that the environment inside the building promotes vitality and well-being, creating a harmonious living or working space. These buildings require the prudent use of sustainable architectural solutions, focusing on the integration of non-toxic materials, effective use of resources, and reliance on natural lighting and energy sources. By combining these elements into a cohesive design, green buildings offer significant benefits to both their occupants and the environment.

The building meets the needs of its occupants and ensures their health, satisfaction, contentment, productivity, and vitality. It requires the prudent use of verified sustainable architectural solutions, construction with non-toxic materials, and effective use of materials derived from sustainable natural resources. Additionally, it relies on the sun for daylighting, thermal, and electrical energy, as well as the recycling of materials. The architectural integration of these solutions results in a building that brings pride to its users and serves the natural world.

Some aspects of green architecture include: 1- increasing comfort, livability, and productivity; 2- improving durability, quality, and maintainability; 3- stabilizing internal environmental conditions; 4- saving money by reducing living costs; 5- realizing the options for high-performance solar buildings; and 6- selecting green building materials to play your part in helping protect the environment.

2.2 Examples of Sustainability in Architecture and Green Architecture

Examples of sustainability in architecture and green architecture include utilizing natural energies in daily consumption and using waste materials, particularly wastewater, for producing water needed for green space irrigation. It also involves employing suitable methods to reduce or control wasted energy and optimize energy consumption, using recyclable non-chemical materials that do not conflict with human health, and designing and constructing with materials close to nature. Preventing the negative impacts of buildings and their products on the environment is essential, as is using natural plants as inspiration for living designs in common areas. Additionally, avoiding damage to land conditions to gain more profit, achieving the highest quality of life through reliance on the environment, and implementing land use methods are key factors. Attention to the ecological character of the area, considering the climatic properties of the region, and paying special attention to the effect of light and air in the design of the whole complex and the arrangement of public and private spaces are also important. Finally, an emphasis on mobility and outdoor living plays a significant role in sustainable architecture.

2.3 Green Materials

When selecting green materials, it is important to avoid using chemical materials that are commonly found in mechanical equipment and insulation. Building materials should be sourced locally to reduce the need for transportation, which helps lower energy consumption and overall pollution. Recyclable building materials or products made from natural sources, such as insulation made from cellulose, homeset, multi-layer boards, recycled brick, and plastic products in the form of boards and coverings, should be utilized. Wood products should be sourced exclusively from managed forests that are certified. Additionally, it is crucial to avoid materials that emit pollutants, such as solvent-based paints and varnishes, carpets, adhesives, wood stains, and other building products that release volatile organic compounds (VOCs).

Since the early 1980s, the scope of building design and construction has witnessed new innovations daily in the field of more efficient and high-performing materials. With continuous progress, the capabilities of materials have increased daily, and humanity has consistently seen the introduction of new materials into the construction industry. Materials used by humans throughout history and past ages have played an undeniable role in shaping the mental space and consequently the life of humans. Perhaps this is why some scholars have labeled human life periods based on the predominant material used during those times as the Stone Age, Bronze Age, Iron Age, Composite Age, and finally the present era as the Age of Smart Materials. Therefore, there has always been a close and unbreakable historical link between construction materials and architecture until the 20th century when the role of materials and technologies in architecture became more significant. In architecture, terms such as Smart, Intelligent, and Adaptive are used to describe structures and materials that include sensors and actuators, which can adapt to external stimuli such as loads and environmental changes. Smart materials are a new term for materials and products that have the ability to understand and process environmental events and respond appropriately. In other words, these materials have the ability to change and can alter their shape, form, color, and internal energy in a reversible manner in response to physical or chemical influences from their surroundings. Smart architecture is dynamic; it means that its main functional parameters change according to need, demand, and changing conditions. A smart architecture can also, like a living system, learn from experiences and use them in new situations, ensuring system dynamism and self-organization.

The main characteristics of smart architecture in green materials include adaptability, dynamism and activity, flexibility and compatibility with the environment, as well as responsiveness and reactivity. In this article, an effort has been made to identify materials that align with green and sustainable architecture, with two of these materials being analyzed in detail.

2.3.1 ETFE

ETFE (see Table 1) is a highly durable, lightweight polymer material widely used in green architecture, especially for roofing and building facades. It allows high light transmission, which helps reduce the need for artificial lighting. Its ability to be inflated and dynamically change transparency makes it ideal for large, flexible spaces. ETFE is also highly resistant to environmental pollution, weather conditions, and UV rays, ensuring a long lifespan with minimal maintenance. ETFE sheets, which are air-inflated cushions, consist of 2 to 5 layers of ethylene tetrafluoroethylene (ETFE) polymer. These ETFE sheets, formed through the extrusion process (where molten

Table 1: *Key Properties of ETFE*

Property	**Description**	**Benefits in Sustainable Architecture**
Material Type	Ethylene tetrafluoroethylene (ETFE)	Lightweight polymer used as a roofing membrane or building facade material
Weight	305 grams per square meter (200 micrometers thickness)	Light load reduces structural demands, lowers transportation emissions
Light Transmission	87-94% visible light, 83-88% UV transmission	Allows natural daylighting, reduces need for artificial lighting
Durability	Lifespan of over 30 years, UV and weather-resistant	Low maintenance, high longevity, suitable for varied climates
Transparency Control	Can change transparency based on air pressure between layers (e.g., matte to semi-transparent)	Dynamic shading and glare control, improves occupant comfort
Recyclability	Recyclable after use	Reduces landfill waste, aligns with circular economy principles

polymer is shaped into the desired form under high pressure), emerge as thin films held by an aluminum frame attached to the building's skeleton. This lightweight and transparent membrane can only withstand tensile stress and handles the external shell's weight and the system's minimum structural load, approximately 220 Pa. ETFE sheets provide excellent insulation for curved and domed structures.

The material offers several advantages, including a very low weight load of 305 grams per square meter with a thickness of 200 micrometers. It provides high transmission of light and UV waves, along with excellent chemical resistance to acids and alkalis. Active shading, superior thermal insulation, and facilitation of natural ventilation are among its benefits. The material is environmentally friendly and highly energy-efficient, with the ability to cover large openings in various shapes. It also features self-ventilation during fire incidents, exceptional durability, no impact from air pollution, and a lifespan of over 30 years.

2.3.1.1 Color, Transparency, and Solar Control

Due to the high light transmission capability of ETFE roofs and the clarity of these roofs, it is highly desirable in applications where visibility of the spectrum of visible light is required. Additionally, colored films can be used. ETFE sheets allow 87-94% of visible light (380-780 nm) to pass through, while the ultraviolet light transmission range (320-380 nm) is also very high (83-88%). It should be noted that ETFE sheets can help reduce energy consumption in buildings, despite their high absorption of ultraviolet rays. The sheets' ability to change transparency and allow or block light as desired is an additional feature. This allows ETFE sheets to be printed with various patterns to reduce light absorption while maintaining transparency. Furthermore, different patterns can be printed on ETFE sheets, and despite the sheets being white, their transparency can be adjusted. The pressure change between the layers can alter the transparency level. This adjustment can create different visual effects, from matte to semi-transparent images.

ETFE sheets can be inflated, meaning they can be engineered into parts and roofs approximately 4.5m wide and up to 1.5m long for larger parts. Larger openings typically require cables or reinforcement grids.

When inflated, several layers can be joined together by air pressure differences to form a single structure. Smaller cushions can be connected and inflated by a single pump. Compared to glass structures, ETFE has a much lower weight and greater flexibility (with a maximum deflection capacity of 15%). Therefore, it is highly desirable for large, flexible spaces.

2.3.1.2 Maintenance

Unlike fabric structures, ETFE sheet is an extruded material, meaning its surface is very smooth. This smoothness, along with ETFE's anti-adhesive properties, prevents the attraction of dirt and dust and any kind of pollution, such as bird droppings, from adhering to its surface. The exterior surface of ETFE roofs does not need cleaning. The internal surface, depending on the level of indoor pollution, may require cleaning every 5 to 10 years. As a result, accessing the roof (which incurs high costs and time for cleaning) can be economically managed. Despite the fact that ETFE sheets are very durable, they can still suffer minor damage. If they do, they can be repaired easily. Any significant damage requires internal access; however, the damaged section can be replaced easily and promptly, with appropriate parts and materials available as needed.

2.3.2 Phase Change Materials (PCMs)

Phase change materials (PCMs) are substances that store and release large amounts of energy during a phase change (e.g., from solid to liquid). These materials are integrated into building components like walls, ceilings, or floors to regulate temperature. When the indoor temperature rises, PCMs absorb heat and melt, preventing overheating. When the temperature drops, they release stored heat by solidifying, stabilizing the indoor climate. Phase change materials (see Table 2) have the ability to change phases (e.g., from solid to liquid) within a relatively constant temperature range. Additionally, the phase change process in these materials usually involves the exchange of a high volume of energy, referred to as the latent heat of phase change. This high heat exchange occurs harmoniously with nature and automatically and intelligently in response to ambient temperature changes. Given these characteristics, these materials have become a unique energy storage capacity for various applications.

These materials are widely used in numerous industries, including telecommunications, transportation, automobiles, satellites, medicine, textiles, greenhouses, and other fields. The first reports of using these materials in buildings emerged around 1940. Since the 1980s, their use in buildings has been extensively studied, and today, their application in the construction industry holds a special position (Zalba B., 2023; Hawes, 1993). These materials can be used in buildings and in separate components for heating and cooling applications, including shutters, sun-facing walls, gypsum boards, underfloor heating systems, ceiling panels, and Trombe walls.

According to the results of a study, the use of phase change materials leads to an increase in room temperature and the storage of approximately 19% energy. Additionally, the use of this material improves thermal comfort conditions by reducing the magnitude of indoor air temperature fluctuations and maintaining the room air temperature closer to the desired level for a longer period.

2.3.2.1 How Phase Change Materials Work

Materials in nature exist in three states: solid, liquid, and gas. When materials transition from one phase to another, they absorb or release a certain amount of heat, known as latent heat. For example, a solid material absorbs heat and, after melting, transitions to a liquid state, releasing a high volume of energy (referred to as latent heat of fusion). Phase change materials have this property where they maintain their

Table 2: *Key Properties of Phase Change Materials (PCMs)*

Property	**Description**	**Benefits in Sustainable Architecture**
Material Type	Organic/inorganic compounds, such as paraffin, salt hydrates, fatty acids	Thermal energy storage material used in building envelopes and systems
Phase Change Temperature	Typically between 20-32°C, depending on material and application	Can maintain interior temperature comfort by absorbing and releasing heat
Energy Storage Capacity	Stores up to 190 kJ/kg of energy during phase change (e.g., solid to liquid or liquid to solid)	Reduces peak energy loads, supports passive heating and cooling systems
Heat Storage Density	5 to 14 times greater energy density compared to traditional thermal storage systems (e.g., water)	Requires less material for the same amount of energy storage
Application Areas	Walls, ceilings, floors, green roofs, underfloor heating, Trombe walls	Improves thermal comfort, reduces need for mechanical heating/cooling
Durability	Long-lasting performance, does not degrade significantly over time	Can be incorporated into building components for long-term energy efficiency
Recyclability	Can be re-used in various building components or systems	Supports circular economy, reduces the need for virgin materials
Environmental Benefits	Reduces energy consumption, stabilizes indoor temperatures	Cuts down on HVAC usage, lowering energy bills and emissions

state within a specific temperature range for an extended period.

This means that these materials act as thermal energy storage systems. When the environmental temperature rises, these materials absorb heat and undergo a phase change (melting), thereby preventing further temperature increase in the surrounding environment. Conversely, when the temperature drops, these materials release the stored heat and transition back to their solid state (freezing), thus maintaining a stable temperature in the environment.

In essence, phase change materials resist temperature increases in the surrounding environment due to their phase change properties, absorbing significant amounts of latent heat over several hours. This process not only increases the material's temperature but also stores energy efficiently. When the environmental temperature decreases, the phase change material releases the absorbed heat, reverting to its solid state and continuing the heat exchange process (Mondal, 2008).

This behavior can be well observed in Figure 2, where the temperature changes and heat absorption occur continuously within the material, maintaining a stable temperature. This latent heat absorption process is similar to the energy storage mechanism in the phase change region.

In phase change materials used in building envelopes, if the selected material has a melting temperature within the temperature range of the same region around noon, the phase change process can occur during the day around noon when the ambient temperature reaches its maximum. Therefore, after the environment heats up and reaches its maximum temperature, the phase change material in the envelope also heats up and reaches its melting point. However, from this point onward, the material continues to absorb thermal energy from the environment but resists increasing its own and the surrounding temperature, maintaining the temperature at the melting point. This process continues until the entire phase change material transforms from solid to liquid, which usually takes several hours. Once the phase change materials have completely melted, their resistance to temperature increase also disappears, but this happens when the peak heat of the day has passed, and the environment has stopped its heating trend. Thus, by using these materials in the building envelope, we have managed to reduce the thermal load of the environment during peak heat hours.

The opposite happens during the solid formation process. Despite the cooling of the air during the night, the phase change material, after reaching its freezing point, resists the temperature drop due to the release of latent heat and the transformation from liquid to solid. This material, through releasing the absorbed

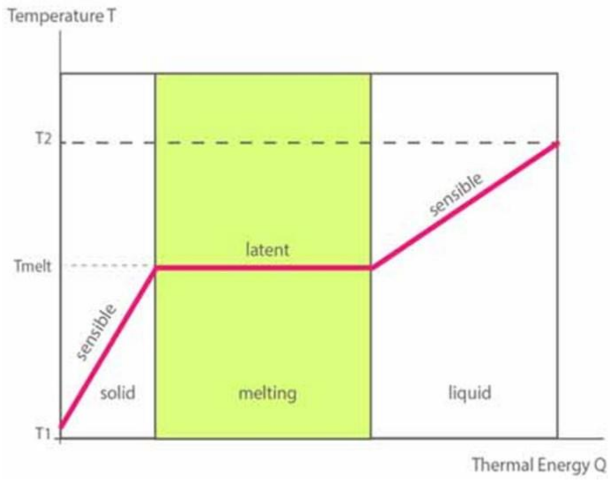

Figure 2: *Phase Change Material Performance (Rathore, 2022)*

heat during the day, prevents the decrease in its own and the surrounding temperature and thereby reduces part of the cooling load of the environment during the cold hours of the night.

Therefore, with the intelligent selection of phase change material and its application in the building envelope, it is possible to reduce energy consumption for cooling and heating during peak hours without the use of additional mechanical equipment. By using the natural capability of this material for phase change, energy consumption is reduced by mitigating temperature fluctuations in the building and providing moderate temperatures during peak hot or cold hours.

One of the important points in using phase change materials is their high density in storing thermal energy compared to other thermal storage methods. For example, a type of phase change material with a melting point of 45 degrees Celsius stores 190 kJ of energy per kilogram. To store the same amount of energy with water, we would need to heat it from 45 to 190 degrees Celsius. A comparison of temperature changes for storing the same amount of energy shows that phase change materials (PCMs) exhibit a temperature fluctuation of around 20°C, water around 40°C, and concrete approximately 180°C.

The melting point of phase change materials varies in a range of 30 to 90 degrees Celsius, which means that the materials that change phase at a range of 20 to 32 degrees Celsius have a better capacity for application in building cooling and heating. In addition to water [5], there are about 500 types of natural and synthetic phase change materials, which have different phase change temperatures. By selecting the appropriate phase change material based on the type of climate zone and the season, this material can be used to moderate the temperature of the indoor air and therefore save on heating and cooling energy consumption.

The use of phase change materials in buildings, considering that the phase change materials maintain their application over a long period, prevents the loss of these materials in different phases. Phase change materials available in the market are used for the consumption of buildings in three states: liquid, solid, and microencapsulated. Additionally, hard panels made of high-density polyethylene (HDPE) plastic contain these materials. To include real-case examples of using ETFE and PCMs, we can mention The Eden Project in Cornwall, UK, which uses ETFE cushions in its biomes to provide thermal insulation and natural light transmission, reducing structural weight, material costs, and energy use for lighting, making it a model for sustainable architecture. Capital Tower in Singapore was the first building in the country to offer WIFI and has since evolved to prioritize energy efficiency and employee well-being. Its advanced HVAC system recovers cool air to reduce energy use, and smart lighting along with IoT sensors monitor air quality, temperature, and CO2 levels to enhance occupant comfort and safety.

2.3.2.2 The use of phase change material in solar systems

One of the capacities of phase change materials is for energy storage in solar buildings that have the ability to collect solar energy. By using phase change materials in such systems, the high volume of solar energy during the day is stored and can be used for heating at night (IP, 1998) (Farid M. M., 2004). The phase change materials in these systems are usually placed in thin layers with the arrangement of plates to store and then transfer heat. These materials work indirectly with water. The method in these systems is such that the collected energy by the collectors during the day causes the warm liquid to move (usually water). This warm liquid transfers its heat to the phase change material plates and then returns. This phase change material delivers this hidden heat to the warm liquid and receives the cold liquid during the night hours, thereby replacing the warm water in the system. The phase change material itself transfers its temperature reduction process (from liquid to solid) to the warm water, causing the warm water to heat up, and then this water is used for building heating purposes. To increase the efficiency of such systems, it is necessary to use techniques that maximize the heat transfer process, and most studies are conducted in this field.

3 The impact of smart materials in green buildings

3.1 Environmental features of ETFE

The energy consumption in the production process of ETFE sheets is very low, and its complete structure weighs about 50 to 90 percent less than similar constructed materials with comparable weight characteristics. Of course, the ETFE system requires more protection to maintain its cover. Part of its materials are made from recycled materials, and at the end of the project, the entire system can be recycled to the construction site to be reused. The long life span and low maintenance and repair costs turn ETFE into a suitable solution in sustainable architecture. The green and sustainable architect can use the smart and thermal cycling light characteristics of ETFE to change the space and functionality of buildings. These capabilities and features make ETFE sheets unique.

3.1.1 Air Dryers

Air dryers can easily absorb air humidity, which is blown into the inside of the pillows. The use of these moisture absorbers is recommended in high humidity environments.

3.1.2 Fire

ETFE sheets have low flammability and are self-extinguishing. In the event of a fire, the ETFE cushions automatically evacuate the fire because the hot air mass causes the ETFE sheet to gather and move away from the heat source, allowing the fire to go out. Since the amount of material present in the roof is minimal, molten droplets of the sheet do not drip down during a fire.

3.1.3 Acoustics

A ceiling with relatively good sound insulation. This means that the sheet acts as a sound absorber for the room and increases the perception and understanding of sounds in the indoor environment.

3.1.4 Thermal Insulation

The U-value of a three-layer cushion is equivalent to 1/96 W/m, which is much higher than the horizontal glass with 3 layers. This means that the vertical glass manufacturers provide figures that are much higher. The characteristics of the cushions, with the addition of layers that have their own light characteristics, can improve the insulation properties.

3.1.5 Durability

ETFE sheet is resistant to UV rays, environmental pollution, and weather conditions. This material, whether in the laboratory or in the external environment, has been tested and no degradation or reduction in resistance has been observed. ETFE does not discolor over time and remains intact. It is claimed that this material has a lifespan of more than 40 years.

3.1.6 Structure

ETFE is used as a replacement for steel cables and does not require any structural support. To achieve wider spans, it can be reinforced with additional cable support.

3.1.7 Water and Steam Insulation

The cushions act not only as a water and steam barrier but also as an insulation for fluoropolymer sheets.

4. The impact of phase change materials on green buildings (Application of phase change materials on green roofs)

Green plant coverings on roofs can be recognized as a passive technique aimed at reducing energy consumption and improving the quality of the surrounding building air. This function can be effective in both winter and summer through heat protection and cooling prevention and the creation of shade. This leads to urban heat island reduction, energy conservation, and internal management of heat rejection. Despite the importance of this topic, the use of green roofs is often limited to energy saving and blocking heat from the sun during the day and releasing it at night. In this context, it is necessary for the materials and resources to be able to store and conceal heat for a long time.

In other words, green roofs that store hidden heat improve the efficiency of the green roof by providing heat in winter and creating shade and cooling in summer. This results in a reduction of the total thermal load required for the building and adding phase change materials in the internal layer of the building intensifies these positive effects.

4.1 Thermal performance of green roofs

The transfer of thermal charge in green roofs is controlled by four mechanisms: shading, thermal insulation, evaporation and transpiration, and thermal mass.

Overall, green roofs reflect about 22 percent of solar radiation, approximately 6 percent of which is reflected through evaporation. Additionally, about 13 percent is transferred to plants and soil, with only 13 percent transferred to the soil alone (Hui, 2009). The effects of green roofs can be divided into two aspects:

The direct impact on the building (internal effect): In this case, the issue is the transfer of heat from the roof inside the building, which reduces this heat exchange and prevents additional energy consumption in the building.

The indirect impact on the surrounding environment (external effect): In this case, the issue is the transfer of heat from the roof to the surrounding environment, which leads to an increase in the cooling load and creates urban heat islands, reducing the temperature and cooling the building's environment.

4.2 Phase Change Materials

As mentioned, phase change materials are used for latent heat storage. This process involves absorbing and releasing heat energy at a nearly constant temperature during the phase change process. PCM can store approximately 5 to 14 times more heat energy than sensible heat storage systems. Therefore, due to the high energy density and the higher energy storage capacity with less temperature fluctuation, PCM systems are more efficient. Despite their specific challenges, they can be applied to walls, ceilings, and floors (PCM). By incorporating these materials, the room's air temperature is significantly reduced and thus improves thermal comfort and reduces energy consumption.

4.3 Objectives of Phase Change Materials in Buildings

The goal of using PCM in buildings is twofold: increasing the building's thermal inertia and reducing the need for heating and cooling, which results in increased energy savings. PCM use can create heating and cooling systems through solar energy and natural ventilation.

4.4 Thermal Performance of Phase Change Materials

It is worth mentioning that the recent use of phase change materials in building applications has been considered for significant energy savings. The performance of phase change materials in buildings is such that during the day, by absorbing heat and as a result, some of the building's thermal energy penetrates into the building wall and melts, and during the night, as the air cools down, they start to freeze and prevent the internal space from becoming warm, and the stored heat is released back to the outside. This reduces the range of external air temperature fluctuations after passing through the wall. This also causes the peak temperature to shift, so it will reduce consumption at peak times, requiring less cooling systems (D. Zhou, 2012).

Since keeping heat and conserving warmth in cold seasons in this climate is vital, the potential for energy savings is provided by using green roofs up to 20 percent if phase change materials are applied along with green roofs. This results in a 36 percent savings due to the short period of warmth in this climate. The high potential of the green roof indicates that it has a high capacity for reducing cooling loads and reducing the need for additional cooling equipment. This is also important because it significantly reduces the need for primary investment in cooling systems in this climate, following economic and environmental considerations. Equipment and costs associated with the transfer of cooling in buildings are eliminated, and on the other hand, the amount of energy required for cooling, which relies on a fossil source, is reduced to zero. This will have an effective role in reducing CO2 emissions.

5. Comparison of ETFE and Traditional Materials

To strengthen the argument for ETFE as a smart material in sustainable building design, it is essential to compare it with traditional materials like glass and concrete. ETFE (Ethylene Tetrafluoroethylene) is known for its lightness (approximately 1% of the weight of glass), superior thermal insulation, and greater flexibility. Unlike glass, which is heavy and prone to shattering, ETFE is extremely durable and resistant to weathering, pollution, and UV light. Additionally, ETFE's transparency can be adjusted for solar control, making it more adaptable to changing environmental conditions. ETFE also requires minimal maintenance due to its self-cleaning properties, while glass requires regular upkeep. In terms of environmental impact, the production of ETFE consumes significantly less energy, and it is fully recyclable, which makes it a more sustainable choice in comparison to glass and other traditional materials like concrete.

6. Challenges and Limitations of Smart Materials

While the initial cost of ETFE can be higher than traditional materials, its overall cost-effectiveness is demonstrated through reduced structural requirements, lower maintenance costs, and energy savings. ETFE structures often require less supporting steelwork due to the material's lightweight nature, leading to cost reductions in the building's framework.

For PCMs, the initial investment is offset by long-term energy savings from reduced heating and cooling demands. Studies have shown that buildings utilizing PCMs can achieve energy savings of up to 20–30% in certain climates. Additionally, government incentives for energy-efficient construction can further improve the economic feasibility.

Additionally, availability can be an issue, as these materials may not be as readily accessible in all regions, potentially leading to increased transportation costs and carbon emissions. Technical limitations also exist; for example, ETFE is primarily effective in tensile structures and may not be suitable for all building types. Similarly, PCMs require careful integration into building designs to maximize their effectiveness, and their performance can vary based on climate and application.

6. Conclusion

In this paper, we explored the fundamental principles and importance of green architecture in addressing the environmental challenges posed by modern urbanization and industrialization. Green architecture, with its focus on energy conservation, sustainable materials, and human comfort, emerges as a vital solution for reducing the negative impacts of traditional construction practices. The integration of advanced technologies and eco-friendly materials, such as ETFE and phase change materials, demonstrates how buildings can achieve a balance between environmental sustainability and the well-being of their occupants. Through intelligent design and the use of renewable resources, green buildings not only optimize energy efficiency but also promote healthier and more aesthetically pleasing living spaces.

Moreover, this paper highlighted the potential of green architecture to transform public perceptions and building practices by emphasizing the value of environmental harmony and resource conservation. The use of innovative materials and techniques can significantly reduce energy consumption, minimize CO2 emissions, and mitigate the effects of climate change. By promoting the adoption of sustainable architectural practices, this approach fosters a long-term vision for ecological balance and improved quality of life. Ultimately, green architecture sets the foundation for a future where buildings are not only functional but also environmentally responsible and aligned with the broader goal of sustainability.

Smart materials like ETFE and PCMs have significant potential in green building design. ETFE offers flexibility, lightness, and durability, while PCMs excel in energy storage and reducing temperature fluctuations. To effectively incorporate these materials, architects should consider lifecycle impacts, installation costs, and potential challenges. Future projects should prioritize their use in climates where their properties can be fully utilized. Combining ETFE with other energy-saving systems enhances overall building performance and sustainability. These materials should be viewed as integral components of sustainable architecture strategies rather than standalone solutions.

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Sustainable Fabric Manufacturing: The Crochet Experience

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Abstract: When it comes to the sustainability of fabrics, the materials used in textile production are frequently given more consideration than the manufacturing procedures. But a fabric's sustainability is also determined by its production techniques. One of the sectors of the global economy that has been shown to have the greatest environmental damage is the textile manufacturing sector. As a result, fabrics produced using techniques that leaves little or no negative impacts to the environment are said to be sustainable or eco-friendly. The study's aim is to promote environmental friendly method of fabric production through the crochet technique and to encourage its exploration in Nigeria. The aim was accomplished by focusing on crochet technique as a sustainable fabric manufacturing technique. The study highlighted ways crochet techniques agrees with sustainability as against the conventional methods of manufacturing fabric. Samples of successful sustainable fabric and other materials produced using the crochet technique were showcased. The economic feasibility and market potentials of sustainable crocheted fabrics were also examined. The study adopted mixture of exploratory and descriptive research methods. In conclusion the study advocated for the acquiring of crochet skill by local textile manufacturers as a way to minimize the negative impact of the production processes of conventional fabric on the environment and also a means of creating jobs for the unemployed youths in Nigeria.

Keywords: Sustainable fabric, Manufacturing, Crotchet, Technique, Environment

Introduction

An overview of sustainable fabric

All that has to be said about sustainable fabric is that it is something that can be preserved forever. In an attempt to counteract the damaging effects of conventional fabric manufacturing procedures on the environment, the textile manufacturing sectors are shifting their focus more and more toward the creation of sustainable fabrics. In general, textile materials produced from renewable or environmentally favorable sources are referred to as sustainably sourced fabrics. The sustainability of a fabric is, however, also influenced by its manufacturing techniques. Sustainable or environmentally friendly fabrics are also those made with processes that have minimal to no negative effects on the environment.

There are several ways to look at how sustainability is applied to the manufacturing or consumption of fabrics, including how the production of textiles or fashion items affects the environment or human population. These effects are seen in three main domains: environmental sustainability, which is focused on conserving resources and materials to lessen carbon emissions and protect the environment. Social sustainability, or the usage of fabrics produced without the use of exploitative labor methods, comes next. The last type of sustainability is economic, which focuses on methods that will result in the creation of goods that the residents of the area can afford. In a nutshell, sustainable fabric production is fabric design and manufacturing done in a way that is more environmentally friendly. Stated differently, the goal of this study is to minimize or eliminate the negative effects that our methods and procedures for producing fabrics have on people and the environment. Sustainable textiles are typically long-lasting and robust. When their life cycle comes to an end, they are frequently made to be recycled or reused.

United Nations Member states adopted the 2030 Agenda for Sustainable Development in 2015, with area of focus on environment, social, and governance. One of the goals adopted by United Nations that will help to achieve the agenda by 2030 is responsible consumption and production. Unsustainable consumption and production pattern have been identified as the main cause of negatively planetary effects of biodiversity loss, climate change, and pollution. Fabric production and consumption pattern has been identified as one of the most environmentally destructive sectors of the global economy. This is because according to Swarna, (2023) the textile industry contributes significantly to global warming, emitting 1.7 million tonnes of CO2 per year, which accounts for 10% of worldwide greenhouse gas emissions.

Fabrics can be made using a variety of techniques, including felting, tufting, bonding, knitting, crocheting, and weaving. But out of all of these methods, crocheting is among the most environmentally friendly ways to produce fabric. This is due to the fact that a variety of yarns, including those derived from sustainable materials like bamboo, hemp, and recycled materials, as well as natural fibers like cotton, linen, and wool, can be used for crocheting. Additionally, the crochet method of fabric creation uses very little energy because it is typically done by hand, leaving no carbon imprint. That is why fabric manufactured using the crochet technique is also categorized as slow fashion. Unlike the machine produced fast fashion that is mass produced, crocheting allows the designer to showcase creative ingenuity in creating unique customized item.

Statement of problem

When it comes to the sustainability of fabrics, researchers frequently pay more attention to the materials than the processes involved in producing fabrics. The textile business releases hazardous chemicals and waste water into the environment during the production of conventional fabrics, which pollutes the environment. One of the sectors of the global economy that has been shown to have the greatest environmental damage is the textile manufacturing sector. The textile industry contributes significantly to global warming, emitting 1.7 million tonnes of CO2 per year, accounting for 10% of worldwide greenhouse gas emissions (Swarna, 2023). As a result, industrialized countries are gradually changing the way they produce textiles in response to growing public awareness of sustainable manufacturing techniques. Regrettably, Nigeria continues to lag behind in terms of sustainable fabric awareness. Due to this, the nation has become a dump for various fast fashion textiles. Consequently, the goal of this study is to investigate crocheting as a sustainable fabric production method that provides an innovative substitute for traditional textile manufacturing techniques.

Purpose of the study

The aim of the study is to promote environmental friendly method of fabric production through the crochet technique and to encourage its exploration in Nigeria. The aim was accomplished by achieving the following objectives:

1. Highlighting ways crochet technique of fabric production agrees with the principles of sustainability
2. Presenting successful cases of sustainable fabric made with crocheting techniques.
3. Examining sustainable crocheted materials' economic viability and potentials.

Significance of the Study

The achievement of this research provides fabric designers with a more environmentally friendly technique which could be used to produce durable fabrics. It can also be used to add embellishment to fabrics created using other techniques. Fabric designers can experiment with various stitches, patterns, and colors, allowing for unique and personalized designs that cater for individual tastes and preferences

Methodology

The study is a qualitative research that employed exploratory and descriptive research methods. Data for the study were collected from primary and secondary sources. The primary data was sourced from personal experience such as creating crotchet shawl, table cloth, crochet rug and observations of students practical works on crocheting. While the secondary data was sourced from textbooks, journals and articles relevant to the topic.

Literature Review

The conceptual frame work for the study is based on the following areas of interest:

Sustainable fabric manufacturing.

Nayak, R., Panwar, T., Grover, T., and Signh, A. (2024) in a recent study stated that the three pillars of sustainability are breached in the supply chain process of clothing and textiles. the study listed environmental pollution, excessive resource use, generation of large amount of waste, greenhouse gas generation, excessive chemical use, child labour and forced labour as some of the problems associated with the manufacturing of clothing and textiles. However, study went further to look at the various approaches that could be implemented in manufacturing of clothing and textile to make it more sustainable. Some of the approaches that was examined during the course of the study were the use of newer technologies such as laser, RFID (Radio Frequency Identification), carbon dioxide dyeing, air dyeing, ozone applications: use of eco- friendly processes; and waste management to reduce environmental impacts. The approaches adopted during sewing operations such as energy saving and waste management were also discussed.

Swarna, (2023) in a study described sustainable textile manufacturing as the process of making textiles using environmentally friendly practices that reduce waste and pollution. This may entail the use of recycled materials like polyester derived from used plastic bottles as well as natural fibers like cotton, hemp, and linen. Apart from using less energy and water, sustainable textile production also uses fewer hazardous chemicals. According to Swarna, (2023) One of the primary advantages of sustainable fabric manufacturing is that it has a substantially smaller environmental impact. Wholesale fabric online manufacturers can considerably minimize their carbon impact by utilizing recycled and natural fibers. Also, they can lessen the amount of pollution produced throughout the production process by using less energy, water, and toxic chemicals.

Bjorkdahl (2022) in a study cited (Ellen MacArthur Foundation) as having noted that in terms of environmental responsibility, sustainability is “embedded” in a substantial part of the West African Textile & Clothing industry. This includes both general sustainable practices and circularity. Firstly, traditional practices of hand weaving and hand-dyeing textiles in West Africa are slow, promoting longevity and quality garments. Made-to-order clothing is also commonplace in African countries - a natural way to mitigate unsustainable production, by ensuring quality and a personal connection to garments. Bjorkdahl further noted that circular practices such as remaking and repairing which many industrialized countries are trying to implement have for a long time been common practice among tailors, designers, and artisans in Africa. Bjorkdahl asserted that clothing production in Africa has often been characterized by sustainable practices.

Patti, Cicala, and Acierno, (2020) in a study reviewed eco-sustainability of the textile manufacturing process, highlighting current issues related to the environmental concerns of the textile productions. In providing alternative solutions for limiting the production of solid textile waste to be disposed, reviewed studies that dealt with the possible applications of the recycled fibers, coming from textile waste, into the world of composite materials. In particular, recycled fibers, mostly based on cotton, were added in thermosetting resins as reinforcement for structural applications, also with the intent to replace the traditional harmful glass fibers. In the thermoplastics, recycled cotton was introduced for obtaining a reinforcing effect in view of automotive components, while the silk and wool were applied for their insulating features in view of printed circuit boards. The idea of reusing of industrial textile waste, or recovery of used fabrics, for realizing recycled fibers, are all centered on sustainable manufacturing practices. This will reduce the use of new raw material with its resultant harmful and toxic chemicals released to the environment during the manufacturing process. Patwary, (2020) In a study investigated the environmental challenges of the Clothing and Textile industry and explores pathways towards a more sustainable production and consumption. It was highlighted that different stages of textile and clothing lifecycles have a different level of environmental impact. For example, the cultivation of natural fibers consumes a large amount of freshwater, whereas yarn and fabric manufacturing consumes a vast amount of energy. Similarly, not all textile fibers have a similar level of life cycle impact. For instance, a cotton fiber consumes a vast amount of water to grow and be processed, whereas a polyester fiber consumes a significant amount of energy during its production. As a result, considering water issues, cotton is worse than polyester; however, polyester would be worse when considering energy issues. Considering all the life cycle stages, a polyester-made product has about double the carbon footprint of that of a cotton-made product (Patwary, 2020) Patwary also identified other impact categories besides carbon footprint for example, acidification, eutrophication, ozone layer depletion, toxicity to humans etc. Therefore, concluded that it is difficult to compare between different fibers and different stages without assessing their whole life cycle impact in a comparable system boundary, unit, and impact category.

Crochet

Crocheting is a handmade technique of looping yarns with hooked needle to produce patterned fabrics. The looped structures that distinguish the modern crafts of knitting and crochet are distinguished by different textile classification systems, claims Cary (2018). Nevertheless, no distinction was made in printed materials before the early nineteenth century. References to what is now known as crochet were hidden when the fabric of either construction was labeled as knitting. The word "crochet," according to Araya (2022) citing Reed, comes from the French word "Croches or Croc," which means hook. A single continuous yarn is used in crochet to produce an interwoven fabric structure.

It is not known exactly when crochet began as a craft or art form, but it is assumed that the practice dates back a few hundred years. Mildred (1979) notes that a lacy type of crocheting considered as a form of American lace was popular in the sixteenth century. Marks (1997) affirms this assertion by quoting Annie Potter an American crotchet expert who stated that the sixteenth century saw the development of the actual crocheting craft as we know it today. Some schools of thought contend that it originated with Chinese stitching, an extremely old style of embroidery that was practiced in North Africa, Turkey, India, and Persia. However, there is no concrete proof that the art was practiced before to the 19th century, when it became popular in Europe. The popularity of crocheting as a technique of fabric production has fluctuated over time, but it appears to have gain popularity in recent times. This is because advancement in modern technology has made it possible for crochet designers to share their techniques and successful works on the social media reaching a larger audience. Moreover, the campaign about sustainable fabric manufacturing practice must have contributed to the recent surge of interest in crocheting.

The fact that crocheted cloth can only be made with hand tools is one of its peculiarities. A crochet hook and yarns are all that are needed to make a crocheted fabric. This makes it appropriate for testing yarns made from recycled or natural fibers to lessen the impact of fabric manufacture on the environment. Additionally, because crochet materials are primarily handmade, the artist is able to create fabrics that are more long-lasting and durable, which promotes slow fashion and a more sustainable approach to fashion.

It has been suggested that crochet can also play a role in promoting positive wellbeing in the general population. Burns and Van Der Meer (2020) in a study investigated the impact of crocheting on individuals 'wellbeing using an online survey based on an existing tool that explored knitting and wellbeing with about 8391 respondents living in 87 different countries. After analyzing the results of the survey, reached the conclusion that crochet offers positive benefits for personal wellbeing. Because many respondents indicated having actively used crochet to manage mental health conditions and life events such as grief, chronic illness and pain. In a related study York, Zhang, Yang, and Muthukumar, (2022) examined how crochet that was embedded in STEAM summer camp impacted students sense of belonging, creativity, well-being and STEAM learning. The study carried out a survey using 37 student participants. Findings from the survey indicated that crocheting enhanced students sense of belonging, creativity and well-being as well as STEAM learning.

In order to provide a theoretical explanation for the study, the theoretical framework work will be based on two chosen theories that are pertinent to the investigation. McDonough's "Design for Sustainability" and the Slow Fashion movement are two of these.

The "Design for Sustainability" book by McDonough offers a starting point for examining how crocheting fits into sustainable design principles. The idea frequently highlights limiting negative effects on the environment, taking social factors into account, and encouraging moral design practices. and the Slow Fashion movement promotes a more ethical and environmentally friendly method of producing textiles and clothing. An examination of how crocheting promotes the ideas of slower, more deliberate manufacturing, prioritizing quality over quantity, and reducing environmental effect is made possible by basing the paper on this trend

The mass production of fast fashion with cheap materials, usually have a devastating effect on the environment. one of the creative solution that seeks to reduce the misuse, waste, and ecological harm of fast fashion is crotchet slow fashion. Because crocheting entails crafting of clothing and accessories deliberately at a pace that considers the interest of the designer as well as the environment. Since it is usually made with hands, it enables each designer to explore the creative ingenuity in producing unique pieces that can be truly one of a kind.

Ways crochet technique of fabric manufacturing fits into the principles of sustainability

Crocheting, as a sustainable fabric manufacturing technique comprises of several features that makes it an environmental friendly method of fabric production.

1. Lower environmental impact: because crocheting is majorly handmade, it leaves no carbon foot print. Therefore, not harmful to the environment.
2. Facilitates reuse and recycling: old used or damaged fabrics can be turned into new beautiful useful material using the crotchet technique. Old knitted or crochet sweater can be loosed and the yarns reused for the production of new crotchet item. This way waste fabrics that would have been disposed by burning or deposited in landfill can be recycled. Crochet is not only a way of giving new life to old fabrics, but resources that would have been used in producing new raw materials are also saved.
3. Enables upcycling of old clothes: old clothes can be enhanced by attaching

some crochet details. For instance, attaching crochet sleeves to sleeves gown, attaching crochet collar to coats or shirts, attaching crochet scallops to skirts among others. Torn fabrics can also be repaired by covering the damaged part with crochet design.

4. Allows for the creation of customized items: it enables one to create unique and quality materials that are more durable instead of constantly buying new clothes or accessories. Even with regular use and washing crocheted materials last long. Because crocheting is often handmade, preference is given to quality over quantity unlike mass produced fast fashion materials that are not durable.
5. Crocheting allows great degree of design flexibility and creativity: designers can explore different stitches, patterns and colour in the same project that takes care of individual customers tastes and preference unlike automated machine produced fabrics that are mass produced. Crochet displays the individual designer's artistry and attention to detail.
6. Adaptability: crocheting techniques can be used for the production of variety of items such as apparels, fashion accessories, home decorations items among others. The adaptable nature of crochet technique enables the production of multi- functional products that fulfills different needs, thus reducing the need for constant purchasing of new products.
7. Comprehensive manufacturing: Without the need for extra input, fabric can be made with crocheting, starting from yarn and ending with finished goods. For instance, you don't need to use a machine or needle to sew when making a crocheted skirt or sweater from yarn to finished item.

Basic crotchet Stitches, abbreviation and how they can be achieved

Ch – Chain stitch; to achieve this make a slip knot, insert hook, take yarn over, draw yarn through loop. Repeat from same for each additional chain until the desired length is obtained

Sc –Single crotchet stitch; to achieve with the crochet hook in right hand, make a slip knot on the hook. Yo from back to front and grab it with the hook. Draw hooked yarn through slip knot and onto hook, skip the first chain stitch, insert hook into center next chain stitch, yo and draw loop through (1sc is made)

Dc – Double crochet; to achieve insert hook into next st, yo and draw loop through, yo and draw this loop through the 2 loops on the hook, (1dc is made)

Hdc –Half double crochet; to achieve yo, insert the hook under top loops of the next stitch. Yo pull yarn through stitch to draw up a loop. There should be three loops on the hook, yo, pull the yarn through all three loops on the hook.

Tr – Treble crochet; to achieve yo, insert hook into next st, yo and draw loop through, repeat yo and draw this loop through 2 of the loops already on the hook, repeat from yo once more, (1tr made)

H tr – Half treble; to achieve yo, insert hook into the next st, yo and draw loop through, yo and draw this loop through all 3 loops on hook (1h tr made)

F sc – Foundation single crochet; to achieve make a slip knot on the crochet hook, then Ch 2. Insert hook in to the first chain stitch, yo and pull up one loop, yo and pull the yarn through the first loop on the hook, yo and pull through both of the loops on the hook (1 single crochet is made

F ptr –Front post treble crochet; to achieve Yo 2times. Insert crochet hook from back to front again around the post of the stitch on the previous row. Pull up a loop, yo. Pull through the 2 loops on the crotchet hook, yo. Pull through 2 loops on crotchet hook, yo. Pull through the last 2 loops on the crochet hook. These steps will be repeated in order to create another ftont post treble crochet.

Slst – Slip stitch to achieve insert hook into next st, yo and draw loop on hook(1dc made)

Sk – Skip

Yo – yarn over

Rep – Repeat

St – Stitch

Steps for Creating Diamond Stitch Crochet

Step 1: With your crochet hook and yarn make a chain of 33

Step 2: In Row1; insert the hook in the 2nd Ch from the hook make 1Sc, continue making 1Sc into the foundation chain until all the chains are exhausted.

Step 3: In Row 2; Ch 2, turn, make 1Dc in each of the stitch all through

Step 4: In Row 3; Ch 1, turn fptr around third Sc of row 1, repeat Sc in the next 3 sts, fptr around last stitch worked, skip Sc sts and fptr around next Sc st. Repeat from to the end. Sc in next sts, fptr around last fptr worked, place Sc in turning Ch2.

Step 5: In Row 4; Repeat crochet work on row 2

Step 6: In Row 5; Ch 1, turn, Sc in the first 2 sts, fptr around first and next fptr, repeat Sc in next 3 sts, fptr around last fptr worked next fptr. Rep from to the end Sc in last 3 sts.

Step 7: In Row 6: Repeat crochet work on row 2

Step 8: In Row 7: Ch 1, turn, fptr around first fptr, repeat Sc in the next 3sts, fptr aroud last fptr worked and next fptr. Repeat to end. Sc in next 3 sts, fptr around last fptr worked, place Sc in turning Ch 2.

Step 9: For the rest of the Rows: repeat rows 4 to 7 until the desired length is achieved to get one side of the fabric. These steps were repeated to get the second part of the fabric.

Step 10. With you crochet hook and yarn make a chain of 15 repeat the stiches in row 2-5 to a width of 10inches and bind off. This step is repeated to get to get the second part of the fabric that will be used for the hand.

Step 11: The two sides of the crocheted fabrics are seamed and the hand attached. See plate 1a for the finished work.

Procedures for Creating Crochet shawl

Step 1: With your crochet hook and yarn make a chain of 300

Step 2: In Row1; work (1dc,2ch,3tr) into 2nd ch from the hook. Skip 4 ch, work (1dc,2ch,3tr)
into the next ch; repeat from beginning to end.

Step 3: Pattern Row; 2ch, repeat (1dc,2ch,3tr) into 2ch space, repeat from beginning to end.

Step 4: Repeat row 2 pattern until the desired length for the work is obtained. Then fasten off. See plate 2 for finished crochet shawl work. Other examples of finished crocheted items are table clothes in plate 3a and 3b, Granny square pattern crochet bag plate 4a, crocheted bag 4b and crochet rug plate 5.

Examples of successful sustainable fabric produced using crocheting techniques.

Plate 1a: *Diamond stitch crochet gown*
Student's project (Erekaka, 2022)

Plate 1b: *Double crochet stitch gown*
Student's project (Erekaka, 2022)

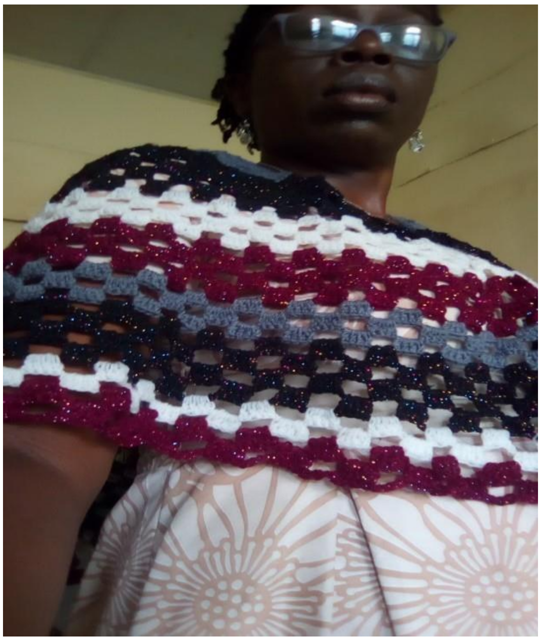

Plate 2*: Crotchet shawl (Source: Okeke 2024)*

Plate 3a: *crotchet Table cloth*

Plate 3b: *crotchet Table cloth*

(Source: Okeke 2024)

Plate 4a: *Granny square pattern crochet bag student's project*

Plate 4b: *Crochet bag*

(Source: Okeke 2024)

Plate 5: *Crochet Rug (Source: Okeke 2024)*

Economic feasibility and market potential of sustainable crocheted fabrics

1. Given their value and longevity, customers are willing to pay higher prices for fashionable crochet products made of long-lasting materials that are simple to fix.
2. You don't need expensive equipment or a lot of space to practice crocheting. As a small enterprise that can be run from home, it can support indigenous craftsmanship and lessen the carbon impact caused by the conventional fabric supply chain's worldwide distribution. In addition to saving the environment by reducing emissions, recycled materials made with the crochet technique also save waste and conserve resources. When an old clothing is imaginatively repurposed using crocheting, the old cloth gains value and there is less of a need for new products, which also results in cost savings.
3. With the high rate of unemployment and economic meltdown that is being witnessed in country, crocheting skill can create a source of livelihood for the teeming unemployed youths by providing jobs with fair income. Money realized from sales of crochet products can improve their standard of living and create prosperity, thus meeting sustainable development goal 8 which is decent work and economic growth.
4. The environmental effects of the chemicals used in the production of conventional textiles can be lessened by using the crochet technique to manufacture fabrics. It might reduce pollution of the air and water, safeguarding biodiversity and fostering a healthier environment.

Conclusion

Having looked at the various fabric products that can be manufactured using the crochet technique, the study is advocating that textile designers should adopt crocheting as a sustainable technique of production. Because it will enable them create highly quality and durable materials that can reflects individual's preferences while having minimal impact on the environment. It is also not a capital intensive business, consumes little or no energy, thus it can be practiced even in the rural area where there is insufficient power supply. Moreover, the adaptable nature of the crochet technique makes it suitable for the production of different fabric materials that satisfies different needs such as apparel, fashion accessories, soft furnishing among others. This ensures a ready market for crochet products. There is a possibility of the market expansion for crocheted products as the awareness for the consumption of sustainable fabric increases. So there are great prospects for people who acquire crocheting skill in the upcoming years.

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Teaching Aperture Design in Architecture: A Pedagogical Approach to Illumination, Structure, and Space

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Abstract: This study investigates the pedagogical approach focusing on the integration of iterative learning, interdisciplinary collaboration, and hands-on prototyping by a project of aperture design within a studio-based architecture course. Therefore, the purpose of this study is to identify the potential of these approaches in improving students' comprehension of the interdependence between apertures and essential aspects of architecture like light and space. The researchers employ a qualitative case-study approach with feedback and collaboration within and across disciplines and four phases of conceptual designing and full-scale mock up construction. The primary objective was to assess how these teaching methods enhance students' comprehension and conception of the relationship between apertures and key architectural elements such as light, structure, and spatial experience.

Undergraduate students of 5th semester architecture at National College of Arts Rawalpindi initiated a systematic, four-stage, conceptual design of openings (doors, windows, skylights etc.) which underwent critique sessions and feedback from fellow students majoring in Fine Arts and Visual Communication subjects. The last step was the creation of life size mock-ups facilitating an understanding by students of how to design and actually build their solutions. The difference in this approach was to try and close the conceptual-practical divide where the students could apply theoretical knowledge to the practical works while getting feedback from their peers and instructors.

The results verify significant enhancement of the student learning in a number of areas, including light control and management, material application, and the balance between beauty and utility of a space. Integrating feedback from other disciplines was also central to broadening the students' design views of a space and aperture design ideas. The repeated application of the design-bid-review-construct cycle encouraged abstract thinking and the assessment of designs depending on performance.

A major contribution of this study is the application of the experiential learning models in architecture and finding that, hands-on design tasks with support from interdisciplinary faculty can meaningfully boost the students' technical lore and conception knowledge. In view of that, future studies could build on these findings and adopt the use of digital technology and assess the experience and impact of such pedagogy at a senior level during the undergraduate study of architecture and interior design.

Keywords: Architectural pedagogy, Prototypes, Explorative research, Light and architecture

1. Introduction

In architectural education one of the most pressing issues is the problem of the discrepancy between the theoretical curriculum and practice. For example, although the distortions of an aperture and distortions of light could be explained to students using traditional teaching techniques, the complexity of how such factors work together in the execution of an architectural design is not well captured in the conventional models of learning. Hence, students often have difficulties in achieving optimal solutions that concern the aesthetic aspect of objects and their purpose. This separation of theory and practice hampers their capacity to fully understand how apertures not only define the space and the experience but also characterise architectural space.

This is essential since aperture layout is one of the main yet simple component of architectural design, which defines the light supply scheme, possibilities of manipulating the inner space concept, and allows influencing the resultant mood within the building. Mostly students do not get a chance to try themselves in how certain aperture influences the light and the material used in the architecture that is pivotal for proper design of architectural spaces. Second of all, interdisciplinary input is mostly lacking, which results in students' limited view of what they are capable of designing. It is for this reason that it becomes pertinent to close these gaps in order to prepare the students to the real world challenges they are likely to face in their professional practice.

While there is a vast amount of work done on the theoretical side of the aperture design, there is limited literature on the practical aspects of teaching this concept by implementing the use of the experiential learning model. The absence of research-based papers regarding the impact of iterative feedback processes, cross-disciplinary collaborations, and life-scale prototype offs on students' understanding of aperture design is a research gap. This research proposal seeks to address that gap by exploring how these teaching techniques may be used to enhance the learning of aperture design to architecture students in a practical manner, with focused emphasis on the studio session.

The research involves architectural students in a systematic, sequential, multiple staged design activities carried out within architectural studios. The challenges that students have to address with respect to light, structure and spatial dynamics are to be embodied in apertures that students will need to design. During this process, they also get inter-discipline input from Fine Arts and Visual Communication students as well as feedbacks from the peers and instructors in the iterative manner. It fosters a prototypical feedback environment where the students will refine their aperture designs step by step and will be driven to think outside the box about their designs.

The main goal of this research is to assess the efficiency of studio-based learning environment in enhancing students' knowledge of aperture design. The assumption here is that undertaking an iterative design process, getting feedback from students from other disciplines, and creating life-scale models will lead to the students gaining a richer and embodied learning about how apertures mediate architectural space. Furthermore, it is the intention of this study to evidence how these forms of experiential learning can promote critical thinking, creative, and problem-solving aptitudes, which are invaluable to architectural training and profession.

To achieve these objectives, the study is guided by the following research questions: How does the feedback provided in the course of this iterative design process help students develop better understanding of how to reconcile utilitarian and formal demands involved in the act of aperture design? How does interdisciplinary collaboration contribute to enlargement of students' perspectives on materiality and space interactions in architecture? And lastly, how does hands-on usage of the tools help the students to apply their theoretical learning into coming up with functional prototypes?

Through addressing the issue of the specific approach to the learning-teaching process and the outcomes of this approach, this paper sets out to bring its input to the discussion concerning the pedagogy of architecture and architecture students, with the emphasis on the applied and the design studio as the principal ways to develop critical thinking and creative problem-solving skills.

2. Literature Review: Theoretical Framework for Aperture Design in Architectural Pedagogy

Aperture Design as a Pedagogical Tool in Architecture

Aperture design is a core component of architectural practice and determines how light impacts architectural spaces as well as the form, performance, and character of structures. Lechner (2014) in his view opines that while discussing about the apertures it is vital to understand that apertures are essential for light control in building since they admit natural light as well as modulate the thermal comfort. Apertures are not only objects with specific functions, but also become visual accents, affect the perception of the room by the user and contribute to the formation of the architectural image. This supports the idea that apertures serve not just a functional purpose but also significantly affect the user's perception of space. By modulating light and thermal conditions, apertures contribute to the overall ambiance and comfort of architectural environments, allowing architects to create more inviting and sustainable spaces. Therefore, teaching aperture design in architectural education is important since it opens understanding of this relationship between light, structure and space.

As known, in architectural education teaching aperture design enables directly considering these basic architectural concepts with students. In the next section, the author draws from Pallasmaa (2009) to emphasize that the control of light in relation to apertures plays a critical role in the development of students' understanding of the qualities of the light that can be felt and hence in the creation of spaces that are friendly and hence the need to consider students' ability to design such friendly spaces. However, despite the teaching of aperture design in architectural education, one finds a gap in the literature as to how this concept can be taught in a manner that can easily be translated into practice. According to Frampton (2020), the design fundamentals must be imparted through a process of osmosis, but student engaging learning models rarely allow them to physically investigate how apertures affect, or form part of, the architectural layout.

This research extends from these concepts by offering a studio-based learning model which includes iterative design cycles, interdisciplinary critique, and full-scale prototyping. It also does so in an effort to solve an architectural education problem that isolates the theoretical discussion of aperture design from practical implementation.

Constructivist Learning and Iterative Design Processes

One of the main components of the discussed theoretical framework of the proposed pedagogy is based on constructivism learning theory. Both Piaget (1973) and Vygotsky (1978) opined that constructivism entails the learning process where students construct knowledge as they interact with the environment. With regard to architectural education, this means that the students grasp knowledge in a best way if they are not only spectators of the design process but active members of it. According to Salama (2016), studio-based context is quite suitable for such enagement as it allows students to test, fail and learn through design and redesign processes. This iterative process helps students not only learn through mistakes but also encourages creative problem-solving, which is essential for developing resilient design skills that can adapt to real-world architectural challenges.

It has also shown how the design process which is so crucial in architectural education strongly resonates with Schön's (2017) iterative theory of reflection-in-action. Schön says that the design studio is a prophetic dialogue with the materials through endless spirals of designing, criticizing the design and redressing the designing. This process of iteration makes the students more equipped in critical thinking and it also provides them information as to how to evaluate their designs in light of given realities such as constraints and standards for performance.

Specifically, the aperture can only be understood and evolved iteratively such that it becomes sensitive to light and the space in which it is placed. A central concept of mechanical design is the ability to build and experiment with aperture designs, which students rarely are given the opportunity to do in traditional architecture programs. In the same manner, Webster (2008) explores that adopting the iterative design paradigm can assist educators in fostering their students' better critical judgement of architectural concepts given that they are exposed to the outcomes of executing conceptual ideas and designs.

The pedagogical approach described in the present study is based on constructivism paradigm of learning, according to which students construct their knowledge through interaction with the environment that provides ideas and stimuli. This is supported by Kolb's (1984) experiential learning theory whereby students enlightened by their practise and its consequence. Compared to other aspects of aperture design, this approach enables the students not only to envision light, space, and materiality but also to manipulate and experiment with their concepts while building full-scale prototypes at life scale. This is also in support of Schön's (2017) theory of reflective practice where students are able to think continually using "reflection-in-practice" and "reflection-on-practice" to analyze their decisions made during the design process and improve on them. By integrating these theoretical approaches into the study, the work fosters further appreciation of architectural concepts attained through cycles of embodied practice as well as critical reflection and feedback loops from peers and tutors that complement the theoretical knowledge students need to address concrete design problems.

Experiential Learning Through Prototyping

Among the major weaknesses highlighted in literature with regard to architectural education, is general exclusion of physical, hands on learning models. As cited by Kolb (1984), experiential learning is the kind of learning that the students experience as they engage in an activity and reflect on the consequences. With regards to aperture, through life scale prototyping the students get an opportunity to see how the design works in real life situations hence getting valuable feedback required in the fine tuning of the designs.

In line with this, Addington and Schodek (2012) observe that this is in tandem with the assertion by some scholars, which holds that the pedagogy of using physical prototypes in architecture allows the students actualize theoretical concepts into tangible materiality. By modeling these, students can explain it practically as relating the aperture to the distribution of light and materials of space and also the feeling of space. Such a learning method can prove very effective in the kinds of knowledge that involve aperture design since the learner has an actual material that is different from the virtual feel that comes with a computer simulation.

The teaching strategy employed in this study integrates formative learning with an emphasis on prototyping and testing of the students' designs as part of authentic practice. Besides enhancing training of the students' technicalities in designs, it also provides them with the ability to think about the ramifications of the designs they create. Sennett (2008) has rightly observed in this context that although this kind of learning by making does aid in breaking down the architecture ideas, it also assists students to reflect upon the object building process.

Thus, according to the literature review, it is possible to state that aperture design should be integrated much more coherently in the system of architectural education. This research, therefore, has to fill the gap as provided by the constructivist learning theories where the iterative design processes, interdisciplinary collaboration and learn through prototyping are involved. From the scholarly findings the outlined pedagogical framework is the foundation for a comprehensive scheme that will allow the students foster critical thinking, creativity and more importantly problem-solving skills both in learning and the actual practical practice of architecture.

Interdisciplinary Collaboration and Broadening Design Thinking

The last and one more key tenent of this teaching/learning framework is interdisciplinarity as it helps the students develop critical thinking concerning architectural design & expands their vision concerning built envirnoments & its impact on the multiplicity of inhabitants. The study by Lawson (2006) just described points to the value of interdisciplinary collaboration, especially in design education in which one works in different perspectives – to the enhancement of creativity. Although interdisciplinary collaboration can enhance the understanding of the experience of spaces in architectural education it can focus on the elements of light and materiality.

Other creative disciplines' input can enhance students' aperture design perspective as it would make them think about the functional concepts alongside with such visual and tactile effects. According to Salama, (2016) interdisciplinary interaction challenges the students to go deeper than the practical constrains of architectural designs, or the feelings and psychological effects that it may instigate. This broader perspective is important in making well rounded architect to design spaces that are not only functional but also have a meaning to the users.

Interdisciplinary collaboration which has been described above also approaches the realities of professional practice of an architect who cooperates with a number of other specialists from different fields including engineers, artists and those who deal with the environment. As Oxman pointed out in the year 2006, the only way to prepare students for this kind of collaborative environment is to ensure that they embrace Design thinking for complex problems so that they can be able to solve such problems holistically. Through the integration of feedback from the other disciplines into the teaching of aperture design, this research seeks to use methods that will prepare students to develop appropriate critical and creative thinking as they work on their designs.

3. Methodology: Teaching and Learning Approach

This research employs a studio-based learning approach where students engage in architectural design projects, passing through the four D's: This means to identify the objectives, define the strategic initiatives, build value-based propositions and engage in realizing them. These stages comprise of the framework of the studio based methodology. In the Discover phase, the students will be exposed to the concepts of aperture in an introduction to architectural design lectures and case studies of architects such as Le Corbusier and Louis Kahn where students will learn on how apertures affect light and space. In this phase, the students gather information on the site location and environment and come up with drawing templates which will prompt the design process from the material stand point of view. This usually involves using peer feedback and critical comments from the instructor Further clarification of these concepts is done in the Define phase. Here, students are forced to justify measurable and tangible design goal and objectives especially concerning the amount of natural light allowed in the rooms while at the same time respecting the architectural and aesthetic aspects of the building. During the Develop phase, it is important that there should be an integration of effort of different experts from various fields. Students from Fine Arts and Visual Communication give their contributions on the sensory and aesthetic considerations of aperture design, which makes the architecture students to come up with the effect and feeling impacts apart from the functional aspect. Last, the Deliver phase involves making full-scale models of student apertures from construction cardboard so that the ideas can be tested with practical applications. The most effective part for them is the hands-on prototyping of apertures that show

how they control the light and space; with feedback, they are able to adjust the designs.

It is based on the constructivist learning theory that state that learning is an active process of the learner in the process of constructing knowledge through interaction with the environment (Piaget, 1973). Thus, it is backed by Schön (2017) and his theory of reflective practice and, according to which, students develop, enact, and then critique their designs systematically. This is learning model which makes it easier for students to associate theory learned in the class with practice, especially in relation to light manipulation and spatial dynamics.

3.1 Research Design

The study employs qualitative case-study research approach that enabled identification of how the students built the designs iteratively using feedback and prototypes. This approach corresponds to Yin's (2018) case study methodology because its purpose is to study a modern day event in its natural setting. This case also has an iterative feedback loop for academic purposes that is inherent in the architectural education process.

The study was done in a period of six weeks at the National College of Arts (NCA) Rawalpindi, with students in the architecture department of the 5th semester. This particular academic context offered the design tools and environment required for prototyping aperture design.

3.2. Studio-Based Learning

The studio environment encouraged active learning through four structured phases: The studio environment encouraged active learning through four structured phases:

- Phase 1: Theoretical Foundation: Aperture design concepts were taught using lecture methods as well as case study of some architects like Kahn and Le Corbusier. The first design exercises included drawing and building simple forms of apertures so students could teach about the effects of light on space.
- Phase 2: Iterative Design and Critique: Adopting maquettes and models, students advanced on their designs; weekly feedback was provided by the peers and the instructors. This made sure that further development preserved technical as well as aesthetic aspects by concentrating on the light use and material.
- Phase 3: Interdisciplinary Collaboration: Students responded to feedback sessions with students from Fine Arts and Visual Communication to get an understanding of the feel and the sensuous attributes of their designs. Most importantly, this cross disciplinary approach helped students to look over functional requirements successfully.
- Phase 4: Life-Scale Prototyping: Only selected designs were produced at life scale As earlier noted, students had an opportunity to test their apertures on life scale prototyping. This phase allowed students to gain understanding of firsthand experience of their decisions in regards to light distribution or material interaction or the dynamics of the space.

3.3. Student Evaluation

Student progress was assessed through qualitative and quantitative methods, focusing on: Student progress was assessed through qualitative and quantitative methods, focusing on:

- Design Complexity: Lighting, material, and structural commodities students' competence to assimilate.
- Material Use: How various materials work in relation to light and space?
- Light Control: Apertures and Their Effect on the Natural Light Management.

An assigned rubric offered quantifiable feedback for each phase to compare the progress in design and technical features.

3.4. Data Collection

The assessment of work created by student groups as well as preliminary sketches and models and full-scale mock-ups was organised in a systematic manner. Prior to data collection, students were informed about the research objectives, and consent was obtained.

Participation was voluntary, and students were assured that withdrawing would not affect their academic standing. Personal identifiers were removed to maintain student anonymity throughout the study. Sketching was done by students and the sketches were reviewed to see how well the students could represent the concepts for aperture design into solutions with functionalities and form. In each sketch, a set of criteria was applied dependent on light control, material interaction, and spatial dynamics that have been discussed in the context of the project's learning objectives. The assessment of the prototypes in terms of light manipulation as well as the spatial experience was done by both looking at the prototypes and touching them. These aspects were assigned by the instructors so as to quantify students' performance in other sub-aspects like; design complexity, light distribution, on use of the material, and functionality and formalism. Data was gathered in multiple forms, including observational notes, student reflections, and physical design artifacts (models, sketches, and prototypes). These diverse data sources provided a comprehensive view of the students' design processes and outcomes

The student reflections were again qualitatively coded where the occurrence of common themes in the responses are named and categorized. First, all the students' reflections were taken and read through to ensure that none of them were missed. First emerged codes stemmed from repeated ideas or terms associated with learning experience such as 'integration of feedbacks,' 'light manipulations,' 'material experiments,' and 'interdisciplinary inputs.' Subsequently, these codes were aggregated under overarching theme areas corresponding to the study's research objectives. For instance, reflections that pertained changes in design approach following feedback from Fine Arts students were under the category of; Interdisciplinary Influence of Design Thinking. Likewise, the following reflections were grouped under the theme "Experiential Learning and Hands-On Prototyping": reflections that focus on changes in thinking regarding aperture design while engaging in prototyping activities. This coding process served to structure the qualitative data into patterns which gave some insights on change in students' conception of aperture over the course of the project. Themes were taken and further examined with regards to the impact that iterative feedback and interdisciplinary collaboration in groups had on students' capacity to apply theoretical concepts in actual design problems.

Limitations: The small sample size limits the study's generalizability. Furthermore, the interdisciplinary feedback was confined to a specific group of students from Fine Arts and Visual Communication, and future research could include broader disciplinary inputs. The qualitative nature of the data also means findings are rich in detail but not quantitatively generalizable.

4. The Design Project

This section outlines the overall project process, from the initial study phase through to the development of the final design. The following subsection provides details of the initial study and conceptualization phase.

Overview of the Design Project: Objectives, Constraints, and Context

Through illumination, tectonics, and spatial habitation, the design project examined apertures in architectural spaces. The main goals were: Investigate how apertures can improve natural light distribution, structural and material configurations, and spatial perception. Site characteristics and materials limitations forced students to design with actual constraints. The setting was learning studios in which individuals worked jointly and offered constructive criticism to fellow students.

Project Process and Methodology

Initial Study and Conceptualization

The first phase of the design process comprised conducting a literature review for aperture design, which outlined the necessary theoretical concepts. The students started with concepts on light control and spatial modulation, and materiality in context with Lechner (2014) & Pallasmaa (2009). This tactile interaction deepens students' understanding of materiality,

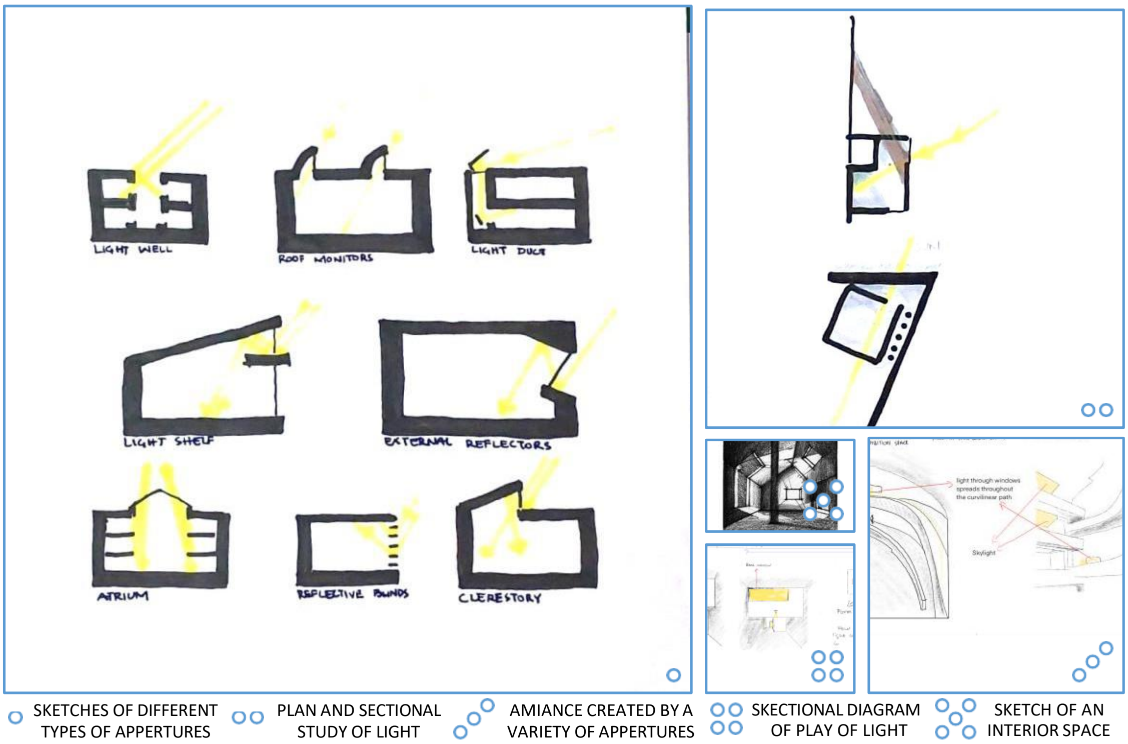

Figure 1: Initial study of appertures by students (source: author generated)

allowing them to critically assess how materials and light interact to create dynamic spatial experiences. It moves the learning process from the abstract to the tangible, enhancing comprehension of architectural concepts.This gave the necessary background knowledge for determining the effects of the aperture inregards to the form and function of architecture spaces. Based on these theoretical findings, students were challenged to advance their first ideas of the design shown in figure 1. Spearheaded by the constructivist learning model (Piaget, 1973), students were engaged in the co construction of knowledge through drawing and computer modellling. Said designs evolved in response to the theoretical concepts, where jut as intended students would translate such concepts as light distribution and interaction between material and work. The approach used was from Schön in the aspect of the reflective practice where students always went back and reflected and modified their conceptual designs on the feedback given.

It then explained how the focus of the research was identified by comparing the architects who have worked on aperture designs or used them in their constructions which included Corb, Scarpa, Loos, Kahn, Chareau Holl, Siza, Aalto, Ando and Le Corbusier. For this they read about their works regarding the application of apertures to regulate light, the partition space, and structural hierarchy (Curtis, 1996; Frampton, 2020). This phase also involved the utilization of maquettes and sectional models to think about spatial organization and aperture performances in several conditions.

Collaborative Analysis and Ambiance Discussion

After the conceptualization stage, the design process enters the feedback iteration stage, which corresponds to the method outlined above. They undertook weekly critique sessions where each of the students showed the progress of his/her designs to the fellow students as well as the instructors. Such sessions were aligned to Schön's (2017) notion of reflection in and on practice, where the students were forced to analyse the critiques they received and come up with informed decisions on how to enhance their aperture designs.

This element together with feedback from Fine Arts and Visual Communication students was important in this phase as it offered the students a more rounded view of design from the artistic and the practical viewpoint. Debating the implications of this feedback process was crucial to embedding changes into their designs; the analysis prying students from purely executing ideas and making them reflect on the artistic impact of apertures reflecting the modality of space; as found by Salama (2016) advocating for interdisciplinary practice in design education.

Later in the investigation, the students photographed the maquettes and the sectional models in order to capture the spatial character as in figure 2. These images were followed by interprofessional group-based lectures with students of Fine arts, Textile and visual communication students. These discussions provided diverse views on the spatial atmosphere, haptic/tactile aspects, and aesthetic, along with architectural research with views from other art forms of arts (P. 52 Salama, 2016). This section outlines the overall project process, from the initial study phase through to the development of the final design. The following subsection provides details of the initial study and conceptualization phase.

Data Collection and Life-Scale Prototyping
In the final stage, students constructed life-scale prototypes of their selected aperture designs shown in figure 3. The hands-on nature of this phase is strongly linked to the experiential learning model (Kolb, 1984), where students learn by doing and reflecting on the tangible outcomes of their work. The prototyping allowed students to test the functional and aesthetic aspects of their designs in a real-world

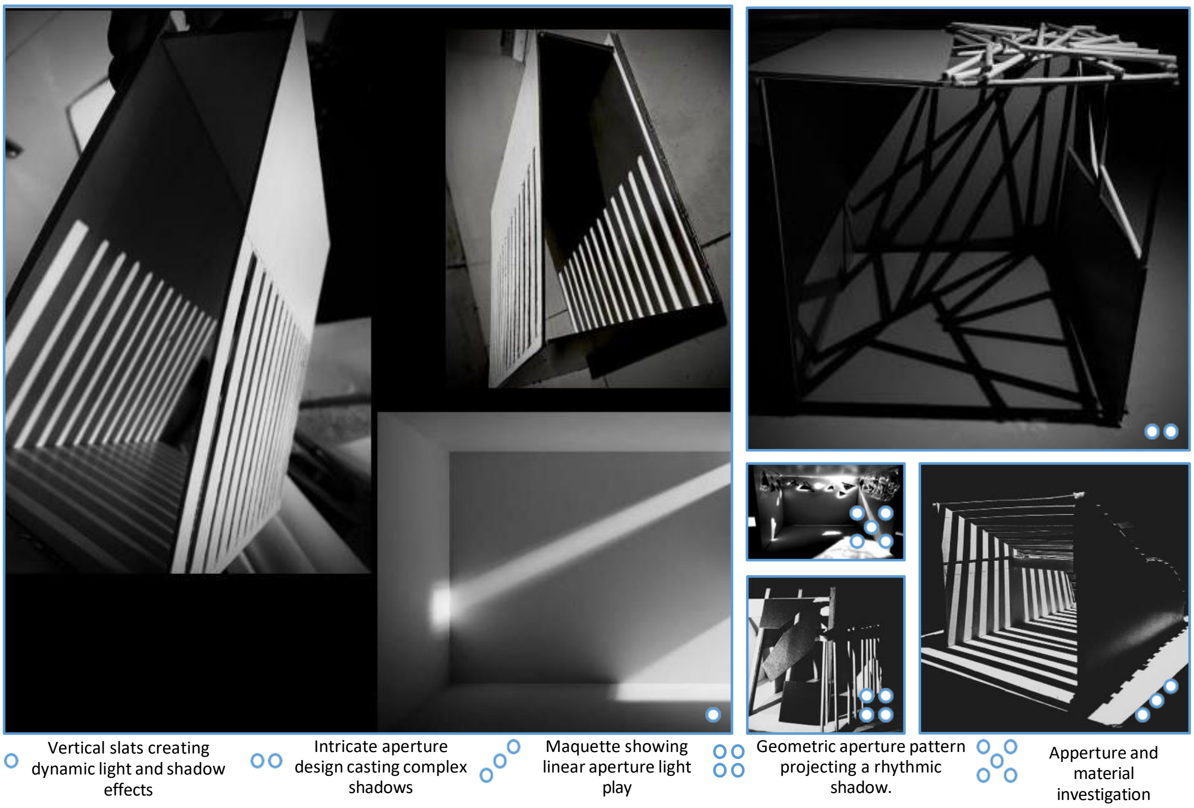

Figure 2: *Study Models to study light and its ambiance in space*

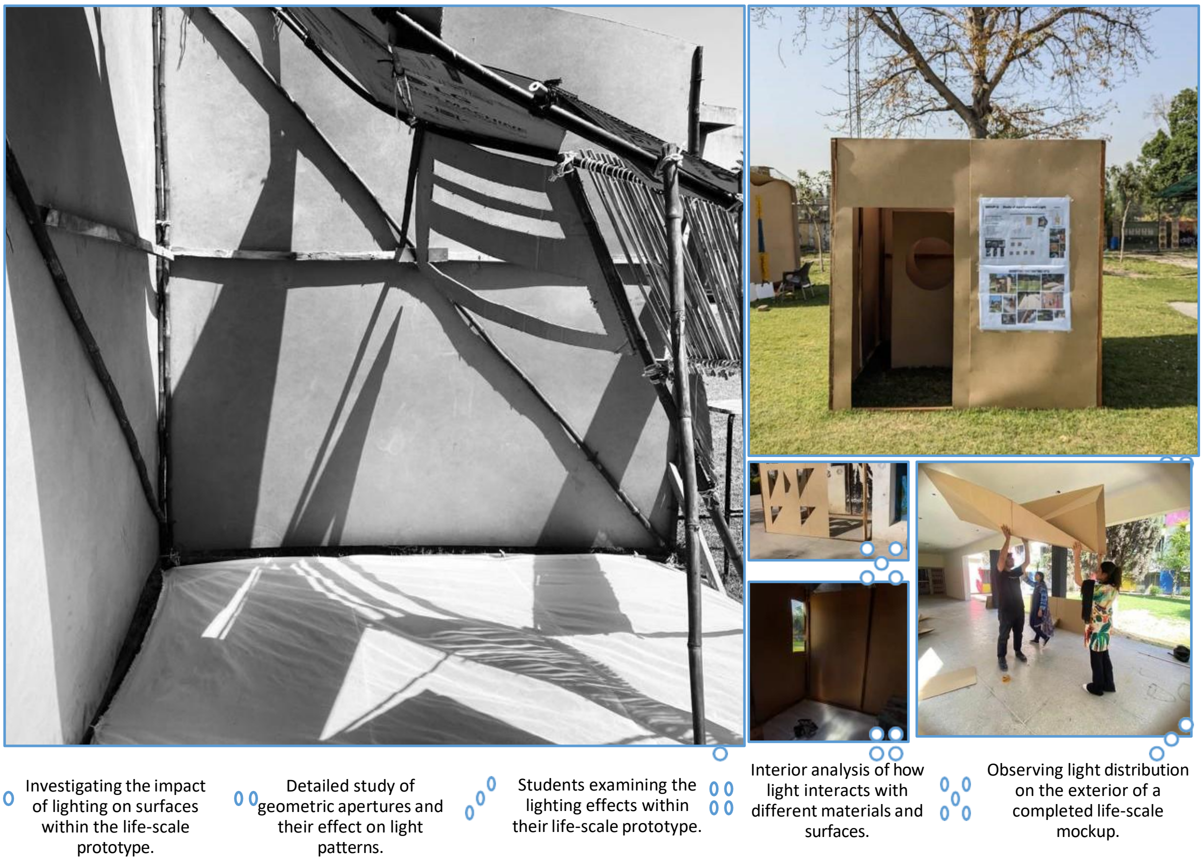

Figure 3: *Process of making Life scale models and studying impact on space*

setting, providing immediate feedback on how their apertures controlled light, interacted with materials, and shaped the spatial environment.

The life-scale models were evaluated based on how well they achieved the design goals established during the conceptualization phase, particularly in terms of light manipulation, spatial experience, and material application. The focus was on ensuring that the theoretical principles discussed during the initial stages were successfully translated into practical design solutions.

Considering these insights from the interdisciplinary discussions, they developed life-scale mockups of their designs. With these prototypes, the students were able to develop real-life concepts of space, light, and materiality rather than purely theoretical constructs. The detailed investigations of each life-scale space involved observations about lighting and how it affected various surfaces and materials within the zones (Addington & Schodek, 2012).

Final Analysis and Documentation

Throughout the design process, students were encouraged to reflect on their learning and design evolution. Student reflections were collected at various stages, providing qualitative data on how their understanding of aperture design changed over time. This reflective process is central to the constructivist and reflective practice models, where learning is driven by self-evaluation and continuous improvement.

By engaging in this iterative and experiential process, students demonstrated a deeper understanding of how apertures impact architectural spaces, moving beyond theoretical knowledge to practical, real-world applications. The last process entailed closely assessing the constructed life-scale prototypes concerning the tectonic work, light survey, and space feel shown in figure 4. These aperture designs stretched natural light from determining the distribution to the structural disposition and the setting of the students' spaces. Consequently, these record offerings of documented buildings were beneficial in understanding the actual use and implementation of design and the theoretical frameworks supporting them (Pallasmaa, 2024).

Prototype Analysis

The prototype analysis involved evaluating the life-scale spaces based on the following criteria:

1. Illumination: The possibility of regulating lighting conditions with the help of aperture placement and configuration.
2. Tectonics: Compatibility of structural elements with apertures to form compact and integrated forms.
3. Materials: The decision-making process regarding the selection of these materials and the effects of their use on light and the experiences of space.
4. Spatial Habitation: The production of purposeful and stimulating environments that enable people to interact and physically navigate.

5. Findings

The project revealed several key findings:

1. Illumination: Good aperture design offers many options for enhancing daylighting without creating a glazing or overheating effect. This light distribution and intensity can be observed in the various solutions students came up with in their prototypes.
2. Tectonics: The arrangement of apertures and structural members was critical in establishing structures, and articulating highlighted different structural systems of frames and shells when working on their aperture concepts.
3. Materials: The use of particular materials and their treatment determined the play of light on space. Light reflected on the shiny surfaces made the place bright, while the smooth surfaces produced softer lighting. In the actual design process, students tested different materials such as glass, wood, and metal to get the expected lighting.
4. Spatial Habitation: The apertures were exceptionally significant in defining the spatial characteristics of the work. Apertures

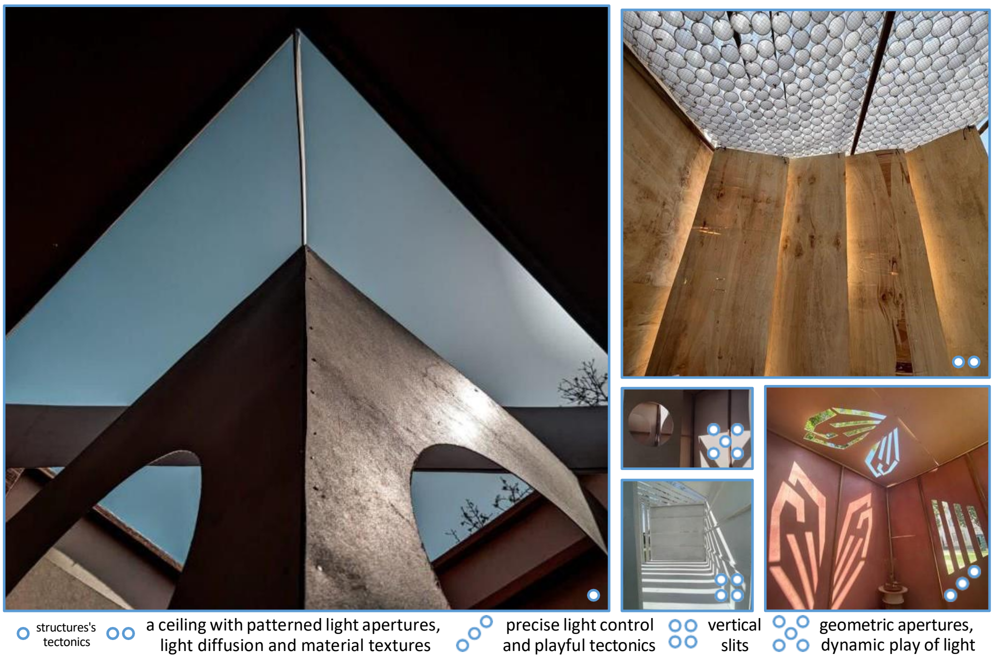

***Figure 4:** Life scale models and light ambiance*

impact the user's view, air, and light to help them understand how to use the space.

6. Results

This section provides the reflection on key learning outcomes of the studio-based design project, highlighting the students' developmental progress over the course of the project as a result of feedback, integration, and practical models. It is structured into three major learning outcomes which underscore the enhancements of students' design skills and their appreciation of aperture configuration within architectural practice.

6.1. Learning Outcome 1: Progression in Understanding Spatial Dynamics and Light Distribution

Analysis of students' sketches and oral presentations revealed a logical evolution of ideas that presented how apertures control space and light interactions. During initial stages of the project a number of students proposed very simple, superficial forms, that were quite weak in terms of the differentiation of light and space. But with consecutive critiques and changes in their design, students slowly started getting the idea of light interaction and came up with better aperture designs to solve such problems as glares, light diffusion, and the level of intensity. Finally, as students remained building on the feedback given, they began exploring the aperture size, aperture position and form as a way of improving the spatial journey. This progression is in line with literature on architectural education where studies indicate that design-challenge based and cyclical learning enhances the students' elaborated understanding of architecture (Goldschmidt, 2014; Salama, 2016).

6.2. Learning Outcome 2: Impact of Interdisciplinary Feedback on Design Processes

These feedback sessions were very useful since they titled across disciplines and helped to enhance students' designs. This was particularly valuable as in their critique architecture students were able to draw on insights from Fine Arts and Visual Communication students to consider the aesthetic and haptic character of apertures. Such feedback made the architecture students to consider more than just the generic parts of their designs and how positions of aperture influence users.

According to the questionnaires; Students indicated that such inter-disciplinary interaction enriched the course by expanding what design thinking entails, that is, the ability to incorporate artistic and sensory dimensions to a design. This is in congrisstenc with other studies that have pointed out the need to embrace interdisciplinarity as a means of enhancing creativity and innovation within architectural education (Frampton, 2020; Salama, 2016).

6.3. Learning Outcome 3: Hands-On Prototyping and Its Connection to Theory.

The hands on prototyping phase provided students with the best opportunity to understand the implications of aperture designs that they have chosen. This method of using life-scale prototypes gave students concrete feel on how aperture and space work with light and materials. A lot of students said that in this phase they gained a much better understanding of the theoretical aspects of architecture because it only made them witness how theories work in real life.

The decision to build the designs physically enabled the students to physically validate aperture position, material choice, and light positioning. This teaching strategy rubs with Schön's (2017) model of reflective practice when learning takes place when a person is testing and developing his plans and work.

6.4. Quantifying Student Progress

Qualitative data were collected as well while the progress of a student was monitored through a recorded quantitative assessment based on rubrics. The rubric measured student performance in key areas such as: The rubric measured student performance in key areas such as:

Table 1: *Quantitative Progress in Student Design Performance*

Criterion	Initial Phase	Mid-Phase	Final Phase	Explanation of Progress
Conceptual Understanding of Apertures	1/5	2/5	5/5	Initially, students had a basic understanding of apertures focused on functional aspects. Through critiques, they grasped how apertures shape spatial experience, improving significantly by the final phase.
Spatial Quality and Light Distribution	0/5	2/5	5/5	Early designs lacked effective light control, often resulting in uneven light distribution. By the final phase, students optimized aperture size, placement, and form to achieve balanced light environments.
Material Interaction with Light	1/5	2/5	4/5	Initially, students chose materials without considering light interaction. Over time, they experimented with reflective, translucent, and opaque materials to enhance the light's effect on space.
Design Iteration and Refinement	1/5	3/5	5/5	Early designs showed minimal refinement, with students not revisiting their ideas. By the final phase, students had iterated multiple times, showing significant improvement in attention to detail.
Engagement with Critique and Feedback	0/5	1/5	4/5	Initially, students were hesitant to integrate feedback. Through the mid and final phases, they became more proactive, incorporating feedback constructively to enhance their designs.
Integration of Aesthetic and Functional Aspects	0/5	2/5	4/5	In the beginning, designs either prioritized aesthetics or functionality. By the final phase, students successfully balanced both, creating designs that were both functional and visually compelling.
Collaboration and Interdisciplinary Learning	0/5	1.5/5	5/5	Early collaboration with other disciplines was minimal. By the final phase, students fully integrated interdisciplinary feedback, enriching their designs with artistic and experiential insights.

• Design Complexity: Capability to design complex and workable aperture structures.
• Light Manipulation: Ability to manage the light distribution, intensity, and glare and placement of aperture.
• Material Selection: An appreciation of how materials affect light and space interaction and the resultant atmosphere.

The table shows clear improvements in each category as students progressed through the design phases. For instance, the average score in Spatial Quality and Light Distribution increased from 0/5 in the initial phase to 5/5 in the final prototype phase, reflecting the enhanced understanding gained through feedback and hands-on experimentation.

6.5. Feedback and Student Reflections

Students also participated in post-project surveys, where they provided reflections on the learning process. Survey results indicated that 85% of students felt that the hands-on prototyping phase was the most valuable aspect of the project, as it allowed them to apply theoretical knowledge in a real-world context. Additionally, 70% of students reported that interdisciplinary feedback sessions significantly enhanced their design thinking.

The feedback highlights the importance of practical, hands-on learning and the value of collaborative, interdisciplinary engagement in shaping students' architectural designs.

6.6. Summary of results:

Table 2: *Student Feedback on Learning Process*

Survey Indicator	Percentage of Students Agreeing
Hands-On Prototyping Enhanced Understanding	85%
Interdisciplinary Feedback Broadened Design Thinking	80%
Iterative Design Process Improved Final Outcome	90%
Integration of Aesthetic and Functional Aspects	75%
Peer Feedback Contributed to Design Refinement	78%
Collaboration Increased Confidence in Design Choices	72%
Improved Ability to Articulate Design Intentions	82%
Reflections on Real-World Applications of Designs	70%
Project Encouraged Critical Thinking and Problem Solving	88%
Gained Deeper Understanding of Material-Light Interaction	79%
The Project Improved My Spatial Awareness	85%
Feedback Sessions Helped Refine Conceptual Thinking	83%

The integration of qualitative and quantitative data show that the studio-based, iterative learning approach enhances the students' design skills and their understanding of aperture design. The inclusion of interdisciplinary feedbacks and the use of the life-scale prototypes helped the participants to understand the characteristics of light, material and space in an integrated manner and within real life contexts as opposed to reliance on the theoretical knowledge.

7. Discussion: Pedagogical Implications

In this project, the integration of studio-based instructional techniques effectively supported key areas of learning in architectural education, based on constructivist as well as experiential learning theories. This discussion demonstrates how the iterative design process, inter-disciplinary collaboration, and hands-on prototyping benefited the students' cognitive processes and design skills based on literature from both educational and architectural fields.

7.1. Constructivist Learning

The teaching approach in this project fully supports the tenets of constructivism learning theories which has been formulated by Piaget (1973) where learning is an active process in which learners engage construct their own knowledge through constructive experiences as opposed to receptive learning where learners are mere recipients of teachers' knowledge. Because of the setting used in the studio, the students were able to interact with the physical as well as the theoretical aspect of aperture design. Through the process of making a maquette, constructive criticism, as well as developing life-scale prototypes, the real-life practice was certainly achieved by all students.

This is in line with the view of other scholars who agree that architecture students grasp concepts better when they are in possession of practical exercises that involve solving design issues (Salama 2016). These findings reinforce the argument that hands-on approaches foster deeper engagement with architectural problems, aligning with the iterative, feedback-driven methodology employed in this study, where students were able to bridge theoretical and practical design skills.In the subsequent phases of the project, the students were able to build additional layers of how apertures affect light, structure and space, in accordance with Kolb's experiential learning theory (1984). They are in line with earlier research about constructivism, especially in studio-based learning, that argues that the development of intellectual skills and designs occurs in a cycle of action-reflection where students experiment with ideas, observe that they fail, and modify or discard them (Schön, 2017).

The ability to build some prototypes on campus meant that students were able to relate architectural theory to spatial construct. This method supports Dewey's (1938) idea of the educational experience should be anchored in learners' transactions to construct knowledge from the environment. In the same vein, Biggs and Tang's (2011) proposed theory found that in active learning contexts such as in the present case where students are provided with design tasks and allowed to self-organise, it helps to strengthen their capacity to integrate knowledge.

7.2. Iterative Learning and Design Thinking

The concept of learning in this teaching approach is the process of iteration which mirrors the principles of design thinking as well as reflective practice proposed by Schön (2017). In regard to this, the project benefitted the students by enabling them to undertake the following processes characteristic of architectural programs: designing, critique, and redesigning.

Literature on use of learning cycle in architectural education has overtime affirmed that more so when learning involves iteration, that is, where more than one attempt is made and the end result is better because of critical improvements made in between; students develop more robust ways of solving problems and the capacity to manipulate more variables in design (Salama & Wilkinson, 2007). The fact that the designs were being reviewed weekly offered students the chance to introduce, modify and adapt their original ideas as they did counter designs from the challengers thus emulating real world architectural practice as postulated by Cuff (1991). Furthermore, the use of the feedback constructively during the final designs indicates that the student's work reflects the design thinking processes that more or less go through such cycles of testing and improving an initial idea over a designing process (Cross 2011). This cyclical refinement not only improved the technical precision of students' designs but also fostered creative risk-taking, a critical aspect of developing innovative architectural solutions.

The iterative process also benefited the development of metacognition within the course because students learned to reflect on the design progress and on their learning process as well. Fisher & Scriven (1997) suggest that processes involved in thinking about thinking or doing meta cognition is imperative for building independent learners for life. In this project, the aspect of metacognition was well displayed as students learned how to identify critical issues likely to arise in the designing process and also probably apply criticism appropriately.

7.3. Interdisciplinary Collaboration

Multidisciplinary integration has also shown to improve the learning process through introducing architecture learners to different paradigms of thinking that they probably would not encounter regularly (Frampton, 2020). Applied in architectural education, this approach stimulates search for novelty as the students work with other paradigms and approaches (Salama, 2016). For example, architecture works together with students from the Faculty of Fine Arts and Visual Communication: as a result, the architecture students are forced to look beyond simple technical issues linked with light, material, and space and expand their vision looking for new opportunities. Besides, this exposure improves their design skills as well as fits in the changing model of education that embraces diplomas from different disciplines at once (Lawson, 2006).

One of the most affecting examples of such outcome was when an architecture student, who first experienced certain difficulties in configuring aperture which should allow simultaneously to deliver enough light and to be beautiful at the same time, read the critical yet constructive feedback of a peer from Visual Communication course. The detour pointed out the emotional and sensory impact of light triggering a redesign of the architecture student's to embrace a more complex modulation of diffuse light. The student admitted, "I did not realize that light can elicit a very powerful emotional response until I got feedback from the Visual Communication student, it changed how I was using the aperture completely. " This example shows how one form of cross disciplinary feedback can impact the students by challenging their design thinking processes to the extent of embracing more of sensory and emotions to the functional aspects of the design.

Such interactions not only amplify the students' designs but also extend their thinking on the impact of aperture on the users; a phenomenon typically masked in normal architectural learning Oxman (2006) concluded that students of architecture are positively impacted by this integration as it fosters structural learning that enables the architecture to solve design issues with diverse forms of knowledge. This collaboration introduces a holistic view of design, allowing students to incorporate perspectives beyond architecture, such as visual arts and engineering. This broader viewpoint enhances the creativity and functionality of their solutions, better preparing them for the interdisciplinary nature of professional practiceWhile this is evident in our study, where interdisciplinary collaboration enhanced creativity, future research could further explore how integrating environmental engineering or urban planning perspectives might enrich students' architectural solutions to modern-day challenges. Chickering and Gamson (1987) also add that when students engage in academic activities by sharing their own views and ideas and by involving in the evaluation of their peers' views and ideas, the process of academic learning takes place.

The implications of this study underscore the training potential of interdisciplinary work in broadening participants' perspectives of design. Through showing that experiential, feedback based learning models can address these issues this work has implications for architectural education more generally. It is suggested that architectural education should include interdisciplinary critique sessions, along with prototype design as a way of improving students' technical competence and depth of architectural thinking for addressing actual architectural issues. These findings imply that comparable approaches of architectural education might be of benefits applied in different architectural education settings to improve the creativity and practical knowledge of future architects.

7.4. Experiential Learning Through Prototyping

The last stage of life-scale prototyping was useful for the completion of the gap between the theoretical knowledge and the experience. Through their constructions, students apprehended how apertures worked within real situations, corroborating or disproving their hypothesis as per the distribution of lights and the qualities of the material and area they involved within their designs. This approach is inline with Kolb's (1984) experiential learning model whereby knowledge is acquired through practice and then fortified by reflection.

In architecture, the use of physical prototyping is very vital in the teaching process because it helps convey to the students how their ideas in their minds will be manifested into physical objects. The most important feature of the presented work was the opportunity of building aperture designs, testing them, and using the results which directly illustrate the given theory. Previous studies on design education highlight the benefits of the haptic essence of interacting with the materials and construction methods to master spatial organization and user experience (Pallasmaa 2009). This aligns with our findings, where students demonstrated a deeper understanding of how light interacts with materials during hands-on prototyping, suggesting that tactile learning accelerates comprehension of complex spatial dynamics.

In addition, the physical models served the form of feedback that is tangible where the build environment point out success and failure of design decisions made by students and some aspects of failure prompt students to reconsider their approach due to realities of the built world (Brown, 2009). This relates to the concept of 'making', one of the teaching paradigms where learners construct, with construction and material experimentation forming an important part of design learning (Sennett, 2008)

8. Conclusion

This paper has outlined the systematic teaching methodology of aperture design in an architectural studio as well as the success of hands-on or iterative approach to teaching. Through design critique, cross-disciplinary work, and life-size prototyping, the pedagogical strategy provided them with ways of contributing to the enriched understanding of architectural thinking and notions of light, structure and space.

The iterative design process helped the students practice a more detailed analysis of their works, driven by both the feedback from their colleagues as well as the instructors. This approach encouraged critical thinking and let the students solve design problems in the way that is close to how architects work daily, in dynamics. Pervasive reflections and revisions helped improve the students' design thinking, pushing them to come up with richer, more nuanced, and better functional and formal solutions.

In addition, the addition of the interdisciplinary review sessions added an additional dimension to students' learning experiences. Students obtained insights about materiality and spatial perspective from Fine Arts and Visual Communication department, which introduced the aesthetics of thinking into the design process with vitality and sensitivity. While this social aspect contributed positively to the creative aspect of the students' work, it also helped them to appreciate how to manage many stakeholders they will encounter in their professional practice in the future.

Finally, it is especially noteworthy that the last phase, or the life-scale prototyping phase, was particularly beneficial for the theory to practice transition. Students could then construct architectural design and its constituents and deliberately examine how the apertures addressed with light and space in real life which was changed intentionally by the students due to the results. For the students this direct experience in the built environment was an opportunity to enhance the translation skills where practical experience was brought about as the concepts were taught. In sum, this pedagogical model applied and effectively cultivated students' ability to solve problems in architecting. Overall, through the conjoining of iterative learning through application and student discussion together with multidisciplinary and tangible prototyping, it stressed the theory by supplementing a strong, thorough, and holistic design thinking as well as problem-solving foundation. It is suggested that the similar paradigms could be of significant value for future architectural pedagogy where students would graduate prepared to address both the conceptual and the practical dimensions of the design process.

Acknowledgment of Research Limitations

This study was conducted in an academic environment and with a limited number of students as subject prototypes, thus the results are not generalizable to a much larger population of students. There was little use of digital media and tools in the designing and product prototyping, though the research work involved hands-on, actual process. Regarding the limitations of the study, the future research could involve a higher number of participants and incorporate advanced digital applications in the design and analysis part to create a wider range of designs.

Directions for Further Research in Architectural Education

1. Digital Tools: Essential features need to emerge through the next stages of this study: parametric design, as well as augmented and virtual reality need to be examined as means to provide students with immersive design experiences.
2. Interdisciplinary Collaboration: Understanding the impact of cross-sdisciplinary collaborations particularly with engineering and environmental science discplines on design thinking.
3. Iterative Learning: The effectiveness could be observed post the students' graduation and longitudinal learning could be done to examine the cumulative effects of iterative learning on the students' designs.
4. Material Experimentation: New investigation for the use of sustainable and smart materials in teaching-design may promote green architectural practices.

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Book Review

Traditional Window Designs of Kirklareli, Turkey

Nevnihal Erdoğan, İzzet Yüksek
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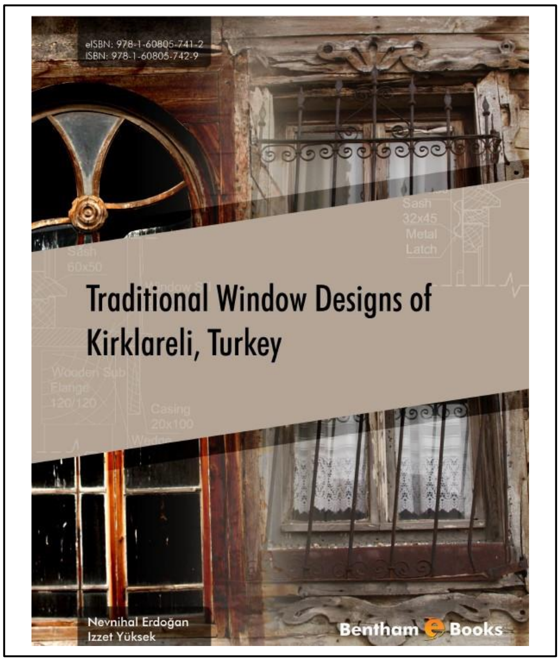

Traditional Window Designs of Kirklareli, Turkey
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This article reviews the book "Traditional Window Designs of Kirklareli, Turkey", authored by Nevnihal Erdoğan and İzzet Yüksek. The book delves into the standardisation of windows found in traditional houses during the late 19th and early 20th centuries within the Kirklareli region of Turkey. Within the scope of the study, 109 houses were examined, and 20 houses were excluded because they lost their original features due to deterioration and destruction. According to researchers, urgent measures need to be taken to protect the cultural heritage in the region. In this regard, one of the book's aims is to contribute to developing new design models by archiving traditional window details. The study examined 103 traditional window types belonging to 89 houses in detail.

The cultural change that has occurred rapidly in recent years is also reflected in the buildings and construction techniques. The materials and construction techniques used in traditional architecture have especially been replaced by different techniques because they are fast and cheap. The wooden frame system, widely used in traditional Turkish architecture, has become standardized due to the necessity of certain dimensions. In this system, the ground floor generally consists of masonry stone walls, and the floors added above it consist of wood frame and infill walls. In the wooden frame system, the spaces between the posts and buttresses that make up the structure are divided by intermediate posts and the gaps are filled with filling material. This standardization ensures window sizes are within certain dimensions, affecting the facade layout.

Erdoğan and Yüksek structured their work through two basic sections. In the first chapter, titled “Traditional House and Window Designs of Kirklareli”, the window concept is generally defined. The position of windows in the building and the window-light relationship are discussed in the context of architectural history. In the study, which examined the 19th and 20th centuries in scope, window examples from that period throughout the world and Turkey were mentioned. The place of Kırklareli province in Turkey is explained along with geographical, social, and economic changes. In addition to general features, traditional houses were evaluated in terms of urban texture, traditional typology, construction system and facade system. The 103 windows are classified by 10 headings. These titles include wall-profile relationship, frame-sash relationship, wing-sash relationship, wing-sash movement, number of movable wings of the profile, window arrangement, movable wings of the profile, fixed wings of the profile, window ratio and presence of details. The literature discussed in this section, which constitutes the theoretical part of the book, is relevant and comprehensive. It will be an important resource for those working on this subject.

“In the second chapter titled "Late 19th Century and Early 20th Century Windows in Kirklareli", the research conducted in Kırklareli is presented in detail and visualized. First, information is given about the general characteristics of the building where the window is located, the structural features of the window are explained, and complementary elements such as sills are mentioned. The features of the window style are mentioned. Later, photographs, scale plans, sections, interior and exterior views and details of the window were added. This presentation style was applied to 103 windows. This section, which discusses fieldwork, offers scaled and comprehensive details, especially for those interested in traditional buildings.

As a result, window type has both visual and functional importance within the traditional housing texture. The deterioration that occurs over time due to natural disasters or external weather conditions causes the tissue and material to deteriorate and cannot be passed on to future generations. In this context, Erdoğan and Yüksek's work has the nature of an archive. The study will make a significant contribution to researchers working in the fields of architecture, design, urban conservation, and planning.

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