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Design-Build Projects in Architecture Education and Experimental Structures as a Pedagogical Approach

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Abstract

The architectural studio and architectural design teaching constitute the basic structure of architectural education. In architectural education, however, the process of "building" or "making" is an essential component of the learning process. Learning by doing is the learning and reinforcement of acquired knowledge and skills by transforming them into practice. This approach is an experience learning strategy that replaces textbooks and classroom lessons, where learning occurs passively, with active participation from the student to maximize effectiveness. As an educational theory, "learning by doing" has important potentials for architectural education. Experimental structures/pavilion designs produced by adopting this approach have recently become increasingly common in the field of architectural education. With experimental structures, students gain different learning experiences including design, structural theory, structure and construction. In this study, an analysis of experimental structures, which are small-scale pavilion applications designed and built by students, is conducted. In the study, 12 experimental structure/pavilion practices conducted by different architecture schools between 2010 and 2022 are analyzed and their place in architectural education is discussed. The results obtained reveal that learning by doing/experiencing by building 1:1 scale structures supports learning in architectural education and should be emphasized in the architectural education learning process.

Keywords: Learning by doing method, Architecture education, Design-build projects, Pavillions, Experimental structures

1. Introductıon

"*For the things we have to learn before we can do them, we learn by doing them. Men become builders by building*.)"
Aristoteles, Nicomachean Ethics [1]

When students analyze the information they learn in theory by seeing, hearing and touching it in practice, they internalize the learning by making it permanent. As a pedagogical strategy, experiential learning is the process of making sense of people's experiences, particularly those in which they are actively involved in doing things and discovering their surroundings [2]. Throughout the 20th century, educational psychologists like David Kolb, Carl Rogers, and John Dewey adopted the idea of experiential learning. According to Kolb, learning is the process by which experience is transformed into knowledge [3].

Bates [4] states that there are different approaches/concepts such as experiential learning, adventurous learning, apprenticeship and cooperative learning within the experiential learning/learning by doing title. A lot of educators advise that practical exercises be included in addition to theoretical instruction. By fostering actual engagement with the subject matter, hands-on activities like building physical models help students develop their structural intuitions [5]. Furthermore, Friedman [6] asserts that the interaction between theory and practice shapes knowledge. Theory and practical application should be connected in this setting.

Learning by doing and practical education have always been important components in preparing the next generation of architects, planners, engineers, and builders [7]. William Carpenter [8] contends that the act of construction in architectural education is a cyclical process that, in this sense, can make the connection between the abstract world and the practical world. Furthermore, according to Walter Gropius, unless students are also given the opportunity to create, their theoretical knowledge in architecture school remains stagnant. Through association, teamwork, and creative collaboration, this educational approach seeks to establish a collaborative environment that enables students to build an integrated approach to learning [9]. In addition to all these, students who actively participate in the learning process through practice design experimental structures with a learning-by-doing approach and gain important experiences in subjects such as design implementation, material selection, and construction techniques. In addition to these, they develop communication, team and professional skills in this process.

In this context, the learning-by-doing approach, which has a great importance in architectural education, has been increasing in recent years with "design-and-build" projects through developing digital technologies [10]. This article focuses on learning by doing in architectural education. In this context, 12 pavilions (pavillion) / experimental structures (experimental structure) designed and produced in the period from 2010 to the present, realized with the learning-by-doing approach, are discussed and their place in architectural education is discussed. In the study, pavilions/experimental structures designed and produced by undergraduate and graduate students studying in architecture departments of different universities around the world were examined. The contribution of these works produced as a result of learning by doing to learning, architectural education and students was

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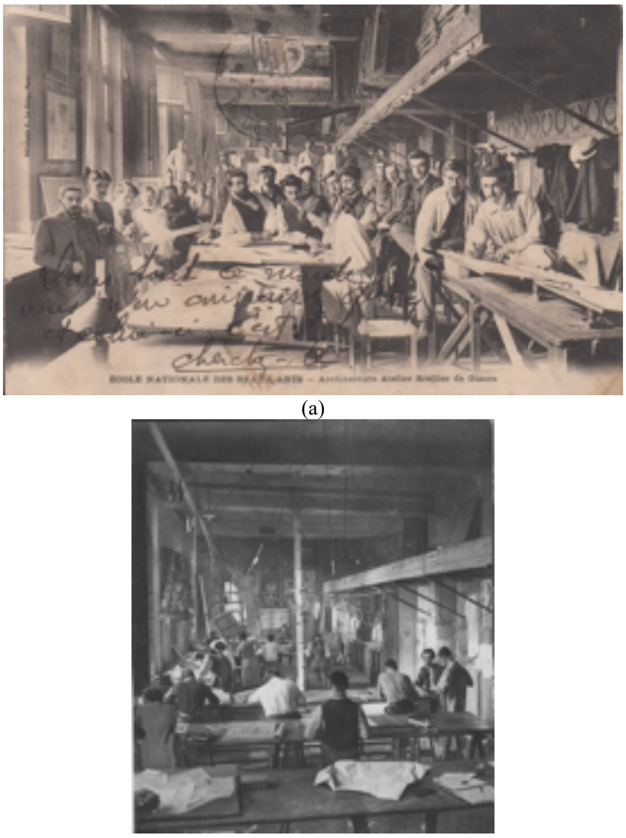
investigated. In this context, the studies (pavilions/experimental structures) were analyzed in terms of whether they were designed with an individual/collaborative approach, whether the production phase was carried out by students or with professional help, what they aimed for, the technologies and materials used in the production process.

2. Learnıng by Doıng in Archıtecture Educatıon

"Learning is experience. Everything else is just information."
Albert Einstein [11]

Looking at the history of architecture, Ecole des Beaux-Arts can be given as the first example similar to the educational approaches and processes followed in architectural design studios that continue today [12]. In this approach, 3 basic forms of education come to the fore and while technical and theoretical information is given in the part realized in classrooms; the backbone of education takes place in workshops. Here, learning is reinforced by seeing and practicing. In the third part of the education, activities such as competitions and conferences are organized to increase the quality of education [13]. However, practical architectural skills are acquired outside of school in specialized workshops run by leading practitioners, many of whom are affiliated with academia (Figure 1) [14].

The design-build approach to architecture education has its origins in Walter Gropius' 1919 founding of the Bauhaus school. Charles Moore established the first design-build studios at the University of Oregon in 1922 [16]. Bauhaus, which has similarities with the Ecole des Beaux-Arts school [17] aimed to consider the profession of architecture holistically by incorporating design-oriented approaches and principles and effectively used the "learning by doing" approach. In the school where the master-apprentice relationship took place, experimental studies were carried out with different materials such as glass, wood, cardboard and metal [18]. In Bauhaus education, learning by doing approach was adopted by supporting teamwork in places such as workshops, laboratories and construction sites (Figure 2) [19].



(a)
(b)
Fig. 1. Ecole des Beaux-Arts Scellier De Gisors atelier [15]; Architecture atelier [14]

Fig. 2. Hands-on activities in the Bauhaus system [20]

Today, in architectural education, where theoretical and practical courses are given together, the environment where the learning-by-doing approach can be used most effectively is undoubtedly design studios. In the studio environment, students can receive feedback by realizing the product they have designed and with this feedback they can revise and improve their initial design ideas [21]. Nonetheless, this is not a commonly used technique, and students typically work with building plans, scale models, and visualizations in architectural design studios. Students are given an alternative full-scale design experience in this setting through design-build projects [22]. But because the design-build method incorporates both design and craftsmanship into its workshop-based learning activities, it is often associated with the Bauhaus school of thought [23]. This method motivates and enhances students' educational and practical experiences [16; 24].

3. Methodology

This research is designed to reveal the current state of the learning by doing approach in architectural education. In this context, the change of the learning-by-doing approach in architectural education from past to present is discussed and the experimental structures produced with design-build projects, which are a continuation of this approach, are focused on. In this context, the structures produced by students in different universities between 2010 and 2022 were researched and evaluated. Thus, through experimental structures/pavilions, the current state of the learning-by-doing approach in architectural education is revealed (Figure 3).

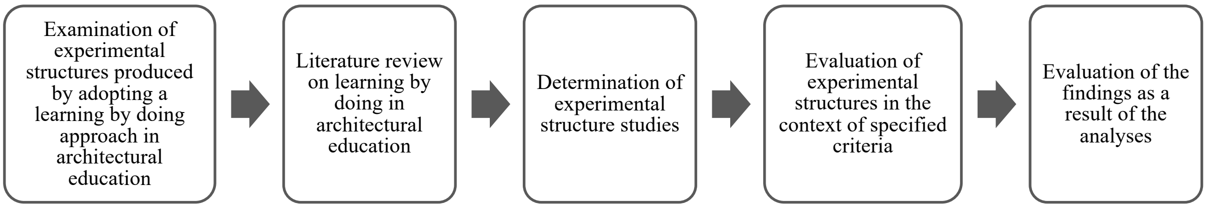


Fig. 3. Flowchart of the research

In this research, which aims to discuss the point where the learning by doing approach has reached within the scope of architectural education with the pavilion designs built between 2010 and 2022; In addition to sources such as books and articles, web pages such as Dezeen [25], ArchDaily [26], Arch2O [27], Parametric Architecture [28], INHABITAT [29], eVOLO [30] were also scanned to reach current examples. The projects on these pages have been selected for review based on the following criteria.

- Being realized in different universities in different countries.
- Design-and-build projects produced in architecture departments.
- Contain innovation and technical innovation: It is important that the examples chosen to study experimental structures are architecturally innovative and technically innovative. In other words, projects that stand out in terms of material use, structural solutions or production techniques are preferred.
- Pedagogical contribution: It is important that the projects are suitable for teaching design-build projects and experimental structures as a pedagogical approach in architectural education. Selecting examples to develop students' thinking skills.
- Sustainability and environmental impact: It is important to evaluate the selected examples in terms of sustainability and environmental impact. Prefer experimental structures that are compatible with the principles of sustainability or have a significant environmental impact.
- Cultural and social value: This group includes experimental structures that have a significant social or cultural impact. For example, this could include designs that reflect the cultural heritage of a particular region or special designs for community use.
- Relevance to teaching objectives: Selecting projects that will enable students to understand specific topics or develop specific skills.

However, in this study, the examples selected between 2010 and 2022 were designed and produced by undergraduate and graduate students studying in architecture departments at different universities around the world. The contributions of these projects, which emerged in the process of learning by doing, to architectural education and students were investigated. In this framework, the projects (pavilions/experimental structures) were designed and produced with an individual or collaborative approach and the role of students or professional help in this process were analyzed in terms of the aims, technologies and materials used. The pavilion examples obtained as a result of the examinations were evaluated in the context of criteria such as student work, professional assistance, materials, design tools, sustainability, production phase.

4. Results

Many educators and scholars have put designing and constructing a pavilion in a studio environment on their agendas in the past few years [31]. Pavilions in particular have evolved into a platform for design-build initiatives in design studios—experiments that combine digital fabrication and parametric design with newly developed design and fabrication technologies. Pavilion architecture is a new paradigm in architectural education that provides chances for experimentation with anything from traditional craftsmanship to digital architecture [32]. Pavilions, which can also be considered as small-scale applications of architecture, have an important place in the history of architecture as experimental structures. These structures, which do not conform to building typologies and have different architectural programs, are also considered as an arena of architectural challenge as they are usually temporary [33]. As an experiment in creating something new, pavilion designs have the potential to not only influence their environment, but also to redefine contemporary architecture, discourse and practice [34]. Thus, it can be said that permanent or temporary pavilions allow architects to experiment with innovative concepts and tectonics.

Within this framework, the study looks at pavilions that were created and constructed between 2010 and 2022. As a digital design project, the Art615 Pavilion was created in 2010 by students from Aalborg University in Denmark's Faculty of Architecture and Design. It is the first example. The workshop aimed to explore the principles of advanced manufacturing and develop spatial systems through the use and modification of diverse digital design methodologies, with the purpose of organizing and communicating social complexities through digital technology. Together with media artists, sociologists, architects, and students, digital tools including Rhino, Grasshopper software, and RhinoScripting were used to generate dynamic architectural concepts. The Art615 project was selected from among the forty-three planned prototypes, and it was then ready for CNC manufacturing and built in full scale using MDF-wood (Figure 4) [35].

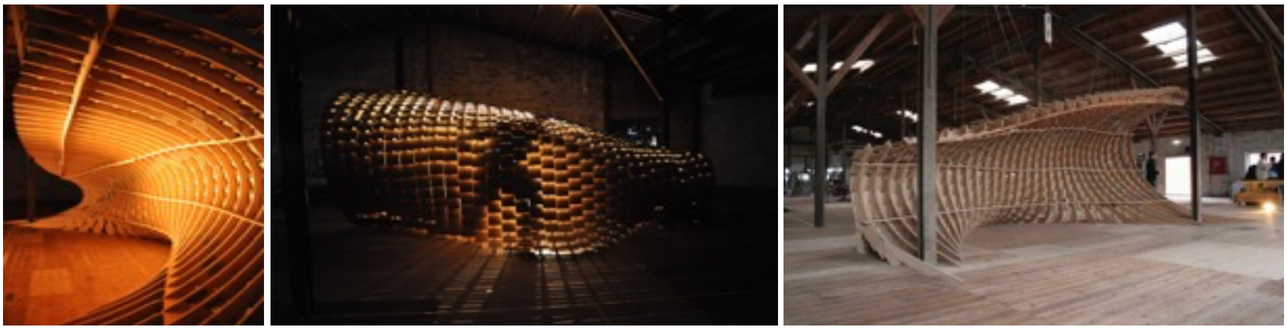


Fig. 4. ART615 pavilion, Aalborg University, 2010 [36]

In 2011, students from the University of Porto's Faculty of Architecture (FAUP) were created and constructed another experimental building. The students were used computational design procedures to examine dome structure design and built a 1:1 scale model out of corrugated cardboard. For prefabrication, 185 hexagonal cells and 185 perforated panels were made in total. Since digital fabrication equipment could not be used, a different technique was used, and the corrugated cardboard panels were cut by hand using contour drawings. The three arches, each made up of nine prefabricated parts, were put together on the ground, lifted, and fastened together using basic bolts (Figure 5) [37].

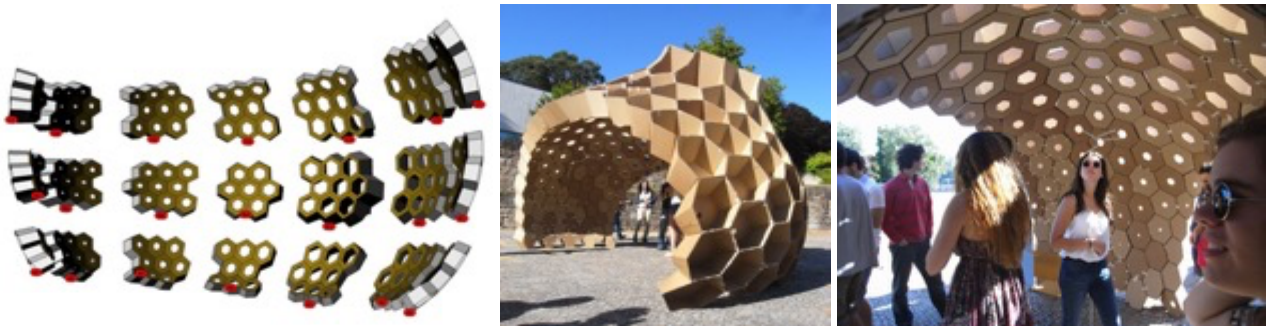


Fig. 5. Constructive Geometry Pavilion, University of Porto, 2011 [38]

In 2013, Obayashi Corporation and the Department of Architecture at the University of Tokyo were collaborated to create and produce Ninety Nine Failures as a component of the Digital Fabrication course. Investigating experimental design, fabrication, assembly, and building processes that cannot be carried out by a professional or educational institution alone was the goal. A series of scale model tests were conducted in conjunction with digital simulations to define the pavilion's geometry. Then, by performing feedback between the computer and physical assembly simulations, the final pavilion geometry's structural and opening performance were ascertained. To create an extremely light framework, extremely thin stainless steel sheets were employed. The three layers of sheet metal that make up each component were formed into a hydraulically inflated metal "pillow," with the edges being welded together (Figure 6) [39].

Fig. 6. Ninety Nine Failures, University of Tokyo, 2013 [40]

In 2014, the Pipe Pavilion project, designed and built by architecture students from Khayyam University of Iran, explored the interaction of conceptual design thinking and the use of digital tools with applied construction techniques. The process involved rapid generation of complex geometric patterns through digital modeling and sustainable construction research. The design, consisting of 1014 recycled cardboard tubes, takes into account the concepts of "sustainability" and "upcycling through the transformation of products into usable materials". The "upcycling" referred to here reduces the use of raw materials as a respectful attempt to reduce the human footprint on the environment (Figure 7) [41].

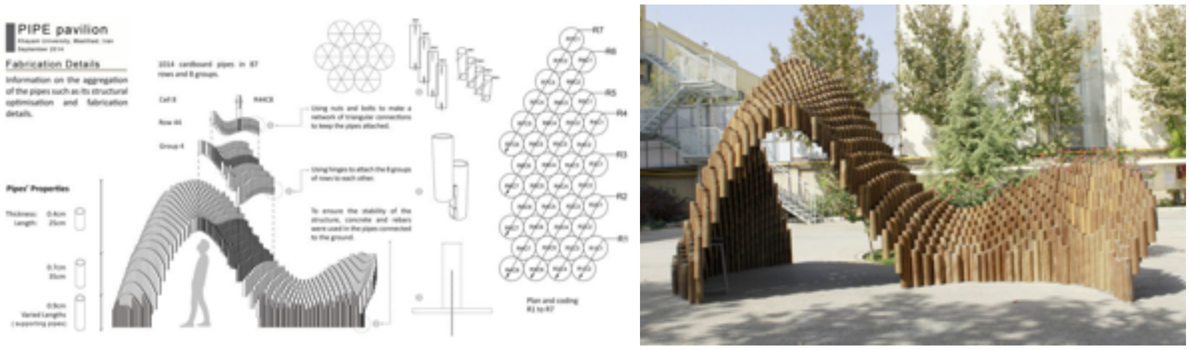


Fig. 7. Pipe Pavilion, Khayyam University, 2014 [41]

From 2015, the Parametric Pavilion was built by the students of the Tecnologico De Monterrey Campus Monterrey. The project started with an algorithm created by a student that created a strong differentiation by placing a pyramid-shaped component on a vaulted surface and changing its height. Another algorithm was developed to laser cut all 195 components by unfolding them on a flat surface and then folding them to create the pyramidal shape from a single 3 millimeter piece of Coroplast. The project team assembled all the components using an industrial staple gun and plastic cable ties, and the structure was reinforced with PVC pipes fixed to the ground (Figure 8) [42].

Fig. 8. *Parametric Pavilion*, *Tecnologico De Monterrey*, 2015 [43]

In 2016, Pontifical Catholic University of Peru architecture students designed and built the Tubotella Pavilion. In the pavilion design, a solution to one of the main ecological problems, environmental pollution, was sought through architecture. In this context, the zero-cost pavilion was created using plastic bottles and Tetra Pak waste, which is abundant in daily garbage [44]. Each module of bottles transformed a plastic container, which was flimsy on its own, into a structural piece that can stand strong together with other bottles. A habitable module was designed in which it was decided to use man-made garbage to develop an innovative construction system that gives a completely different meaning to the concept of "garbage" (Figure 9) [45].

Fig. 9. Tubotella pavilion, Pontifical Catholic University of Peru, 2016 [44]

The Shingled Timber Pavilion was developed by students at ETH Zurich in 2017. In order to save waste during construction, students from ETH Zurich's Digital Fabrication school designed and built the shingled timber pavilion utilizing robotic manufacturing processes. As part of continuing study into the use of robots in the manufacture of wood, educators and students at the Swiss University's Gramazio Kohler study Laboratory created and constructed the structure [46]. The Shingled Timber Pavilion design utilized computational design and robotic fabrication to create a two-story timber structure. Throughout the project, numerous prototypes were designed, fabricated, tested and refined to create the final product. To produce the final proposal, a new robotic setup was developed consisting of two large-scale industrial robots on a linear track. In this automated process, the robot precisely pre-cut more than 4000 different elements and assembled them into large component parts to form the structural elements (Figure 10) [47].

Fig. 10. Shingled Timber Pavilion, ETH Zürih, 2017 [48]

Designed as Studio One by Schleicher and colleagues [49] at the University of California (UC) Berkeley School of Environmental Design's Department of Architecture, the program brought together expertise from biology, engineering, and architecture to conduct research. In 2018, students studied how structures in the plant kingdom successfully combine high robustness and high flexibility, and designed a system based on structural principles seen in the skeletons of fibrous cacti [50]. In this instance, the students' investigation began with an analysis of the material distribution and fiber configuration in the skeletons of dried cacti. Students used computer models to ascertain the pavilion's precise geometry and examine the stresses in the strips of carbon fiber reinforcement that are twisted elastically. A pavilion consisting of 19 mm thick ACX plywood sheets and 1.4 mm thin CFRP (carbon fiber-reinforced plastic) strips was built to evaluate the viability of cactus-inspired design concepts (Figure 11) [49].

Fig. 11. Studio One Research Pavilion, UC Berkeley, 2018 [49]

ETH Zurich architecture students designed and built the Digital Bamboo pavilion, which explores combining natural bamboo material with digital fabrication [51]. Designed with digital design tools, the pavilion is 3D printed from 380 armatures connecting 900 bamboo elements, a high-strength recyclable UV-resistant thermoplastic and stainless steel. The constructed pavilion weighs only 200 kg, covering an area of more than 40 square meters and protruding almost 5 meters in three directions [52]. Because of its extremely low weight-to-strength ratio and quick development, bamboo is a sustainable building material. Digital Bamboo presents a novel perspective on how digital fabrication may contribute to a sustainable future in the building industry by fusing locally available materials with 3D printed components to create a new architectural expression (Figure 12) [53].

Fig. 12. Digital Bamboo pavilion, ETH Zürih, 2019 [54]

Every year, the Institute of Building Structures and Structural Design (ITKE) and the Institute for Computational Design (ICD) create and construct experimental structures using various principles. In 2010, the professionally supported livMatS Pavilion was built in the Freiburg Botanical Garden. The work is a combination of architecture, engineering and biomimetic principles to investigate how effective, efficient and resource-saving energy and material use can be integrated into architecture. In Central Europe, this is the first building with a load-bearing structure entirely composed of robotically wrapped flax fiber, a naturally renewable, biodegradable, and locally accessible material. An interdisciplinary group of University of Stuttgart ITECH students and ICD/ITKE academics developed the computational design process, robotics, and research into the novel material system. The project's industrial partner, FibR GmbH Stuttgart, produced the fifteen structural components (Figure 13) [55].

Fig. 13. livMatS Pavilion, ICD/ITKE University of Stuttgart, 2020 [55]

In 2021, the Wander Wood Pavilion was robotically fabricated on the University of British Columbia Campus. Constructed by the application of industrial robotics, the pavilion aims to showcase the ways in which contemporary technologies and antiquated materials can transform our structure. After learning about robotic CNC milling, digital workflow management, advanced design, and structural principles for timber building, participants were exposed to new prospects and difficulties related to timber constructions [56]. The wood material was chosen because it is a sustainable and renewable resource. Using parametric software and computational tools, architecture students collaborated with outside partners to build and assemble the timber pavilion for the university's public green space. Digital modeling was used to build the organic form out of wood, which was then divided into portions that were robotically cut and arranged [48].

Fig. 14. Wander Wood Pavilion, The University of British Columbia, 2021 [57]

With the assistance of industry partner Loci Robotics, University of Tennessee architecture students constructed the 3D-Printed Pavilion during the autumn semester of 2022. The pavilion's three-lobed, 3D-printed structural dome design was influenced by the double-curved surfaces and radial geometries of 60 and 120 degrees present in the native plant Trillium tennesseense. The students designed and produced a large-scale structure in partnership with an industrial organization. Students worked with robotics experts and gained knowledge about sophisticated materials and additive manufacturing in addition to the hands-on experience. The creation of a thin, light structural shell is one of the research's breakthroughs. Carbon fiber, which is recyclable and can be used to create new prints, serves as reinforcement for the thin shell [58].

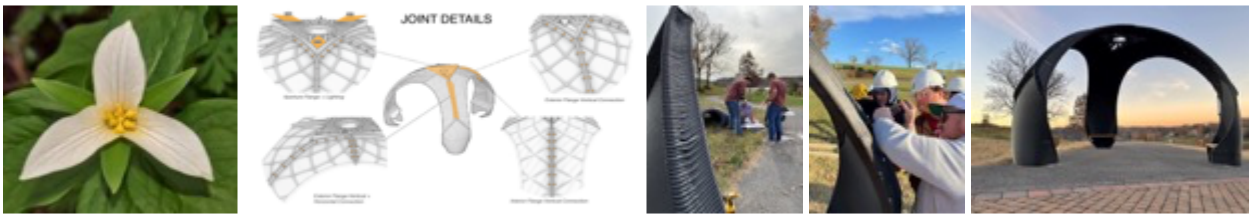


Fig. 15. 3D-Printed Pavilion, University of Tennessee, 2022 [58]

The experimental structures designed and constructed by architecture students at different universities between 2010 and 2022 were evaluated in the light of the data obtained.

5. Evaluation

In the investigation carried out as part of the study, twelve experimental structure / pavilion design examples obtained between 2010 and 2022 were questioned as to which problem they seek to solve, their interdisciplinary working status, whether they were realized in relation to professional teams, the technologies used in design, the material(s) and technology(s) used in production. The evaluations made as a result of this inquiry are presented in Table 1.

Table 1. Evaluations of the designs reached

Pavilion Name Year	Image	Interdiscip-linary study	Cooperation with professional team	Materials	The Problem	Digital technology usage

Art615 2010		Students, architects, media artists, sociologists	Cooperation with CNC manufacturing companies	Renewable, biodegradab-le material MDF/Wood	Dynamic architectural concept research	Rhino, RhinoScripting, Grasshopper
Constructive Geometry Pavilion 2011		Students	-	Corrugated cardboard	Lightweight structure design	Rhino, Grasshopper
Ninety Nine Failures 2012		Students	-	Steel sheet	Lightweight construction design	Rhino, Grasshopper, FE simulation tools
Pipe Pavilion 2013		Students	-	Recycled 1014 cardboard pipe	Sustainabi-lity Reducing environmental footprint	Rhino, Grasshopper
Parametric Pavilion 2015		Students	-	Coroplast and PVC material	Parametric design research	Rhino, Grasshopper
Tubotella Pavillion 2016		Students	-	Plastic bottles and Tetra Pak waste	Research on solutions to environmen-tal pollution	-
Shingled Timber Pavilion 2017		Students	Collaborati-on with robotic manufactu-ring company	Wood	Minimizing waste generation by using robots in wood production	Rhino, Grasshopper, Robotics technologies
Studio One Research Pavilion 2018		Students, Biology, architecture, engineering	-	CFRP strips and 19 mm thick ACX Plywood sheets	High flexibility and resistance	Rhinoceros Kangaroo Physics Grasshopper
Digital Bamboo pavilion 2019		Students		Bamboo UV-resistant thermo-plastic and stainless steel	Lightweight and high strength structure	Rhino, Grasshopper, Digital manufacturing technologies
livMatS Pavilion 2020		Students, engineers, architects, biologists	Robotic production cooperation with FibR GmbH Stuttgart	Flax fiber	Lightweight, high resistance, sustainabi-lity	Digital software and manufacturing technologies
Wander Wood Pavilion 2021		Students	-	Wood	Sustainable and innovative technology research	Rhino, Grasshopper, Robotic Technologies, CNC

3D-Printed Pavilion 2022		Students	Loci Robotics	Carbon fiber	Biomimetic lightweight and high strength structure	Rhino, Grasshopper, Robotic technologies

In the light of the analysis so far, the projects analyzed were grouped according to themes, methodologies and results. The examples were evaluated in terms of innovation and technical novelty, pedagogical contribution, sustainability and environmental impact, cultural and social value, and relevance to teaching objectives. The data obtained in this context are presented in Table 2.

Table 2. Classification of the examples according to themes

Grouping according to themes	Project name	Project Goal
Innovation and technical novelty	Art615, 2010	Using and adapting different digital design methods to explore advanced fabrication principles, developing dynamic architectural concepts
	Constructive Geometry Pavilion, 2011	Learning from nature for lightweight and high strength dome design, investigating dome structures using computational design processes
	Ninety Nine Failures 2012	Lightweight and high strength structure design, innovative architectural design research
	Pipe Pavilion, 2013	Exploring the interaction of conceptual design thinking and the use of digital tools with applied construction techniques
	Parametric Pavilion 2015	Production with PVC pipes, staple gun and plastic cable ties
	Tubotella Pavilion 2016	Design of a habitable module utilizing man-made waste to create an innovative construction system
	Shingled Timber Pavilion, 2017	Integrating robotic techniques to produce construction with minimal waste
	Studio One Research Pavilion, 2018	Building a robust biomimetic structure with high strength with fiberboards, developing new design and construction principles
	Digital Bamboo Pavilion, 2019	Investigating the creative fusion of digital manufacturing and biomaterials
	livMatS Pavilion, 2020	Innovative sustainable biomimetic production techniques
	Wander Wood Pavilion 2021	Exploring the technology to develop innovative material applications
	3D-Printed Pavilion 2022	3D printed lightweight and high-strength structural dome form research and innovative manufacturing
Pedagogical contribution	Art615, 2010	Students learn through hands-on experiences, research, and experimentation that connects digital parametric drawing, dynamic light control, and CNC manufacturing techniques.
	Constructive Geometry Pavilion, 2011	Developing cooperation, communication and problem solving skills
	Ninety Nine Failures 2012	Examination of experimental design/fabrication/assembly/ construction processes, development of collaboration, communication and problem solving skills
	Pipe Pavilion, 2013	Experiencing the design-build process and problem solving
	Parametric Pavilion 2015	Experiencing the 1:1 scale design-build process, learning through collective collaboration
	Tubotella Pavilion 2016	Experiencing the design-build process and problem solving
	Shingled Timber Pavilion, 2017	Experiencing the design-build process and problem solving with robot-human collaboration
	Studio One Research Pavilion, 2018	Investigation of experimental design/fabrication/assembly/ construction processes for the development of new design and construction principles
	Digital Bamboo Pavilion, 2019	Investigation of experimental design/fabrication/assembly/ construction processes for the development of new design and construction principles with 3D printing technology
	livMatS Pavilion, 2020	Investigation of experimental design/fabrication/assembly/ construction processes with biomimetic problem solving
	Wander Wood Pavilion 2021	Experience the design-build process with digital production technologies
	3D-Printed Pavilion 2022	Developing cooperation, communication and problem solving skills
Sustainability and environmental impact	Art615, 2010	Use of natural materials
	Constructive Geometry Pavilion, 2011	Incorporating environmental concerns such as lighting and ventilation into the design
	Ninety Nine Failures 2012	Highest porosity to let in light and reduce wind pressure load
	Pipe Pavilion, 2013	Investigating sustainable and recyclable processes with recycled cardboard pipe
	Parametric Pavilion 2015	Learning the use of digital production techniques
	Tubotella Pavilion 2016	Production with recycled etra Pak bottles and cans
	Shingled Timber Pavilion, 2017	Innovative production to reduce construction waste

	Studio One Research Pavilion, 2018	Reduced material use, highly flexible building design
	Digital Bamboo Pavilion, 2019	Use of sustainable building material such as bamboo
	livMatS Pavilion, 2020	Use of naturally renewable, biodegradable sustainable materials
	Wander Wood Pavilion 2021	Reducing waste through the use of natural materials and sustainable production techniques
	3D-Printed Pavilion 2022	Reducing material use
Cultural and social value	Art615, 2010	To organize social complexities, to provide a sense of a safer environment for crime-related park visitors, local cultural production and formal discussion of social potentials
	Constructive Geometry Pavilion, 2011	Examining the logics of mass customisation and close teamwork
	Ninety Nine Failures 2012	Exploring structural, material and spatial perceptual experience
	Pipe Pavilion, 2013	An initiative to reduce the human footprint on the environment
	Parametric Pavilion 2015	Production of aesthetic design
	Tubotella Pavilion 2016	An initiative to reduce environmental pollution
	Shingled Timber Pavilion, 2017	Minimizing material waste by reducing construction waste
	Studio One Research Pavilion, 2018	Developing flexible building designs that are beneficial for society
	Digital Bamboo pavilion, 2019	Offering a unique perspective on how digital fabrication might contribute to a sustainable future in construction, this project combines locally sourced materials with 3D printed elements.
	livMatS Pavilion, 2020	Reducing environmental pollution through the use of local material resources
	Wander Wood Pavilion 2021	Revitalization of public spaces
	3D-Printed Pavilion 2022	Revitalization of public spaces
Compliance with Teaching Objectives	Art615, 2010	Learning with interdisciplinary and experimental approach in education
	Constructive Geometry Pavilion, 2011	Compliance with the design-build / experimental production process
	Ninety Nine Failures 2012	Compliance with the design-build / experimental production process
	Pipe Pavilion, 2013	Compliance with the design-build / experimental production process
	Parametric Pavilion 2015	Compliance with the design-build / experimental production process
	Tubotella Pavilion 2016	Compliance with the design-build / experimental production process
	Shingled Timber Pavilion, 2017	Suitability for a design-build / experimental production process involving robots
	Studio One Research Pavilion, 2018	Compliance with the design-build / experimental production process
	Digital Bamboo pavilion, 2019	Compatibility with the design-build / experimental production process with the use of 3D printing
	livMatS Pavilion, 2020	Learning with interdisciplinary and experimental approach in education
	Wander Wood Pavilion 2021	Compatibility with new techniques such as robotic construction and design-build/experimental production process
	3D-Printed Pavilion 2022	Practical knowledge and reciprocally advantageous learning outcomes

The findings of the research for this study show that learning by doing or learning by experience is a popular and successful teaching strategy in the field of architecture. Through experience and the development of practical skills, this approach helps students prepare for a career in architecture.

Wood is generally used in the production of the analyzed buildings. The reason for this is generally stated as being a renewable, sustainable and easily available material. However, there are also searches for sustainable innovative materials such as bamboo and flax fiber. The search for solutions to today's environmental problems with the use of waste materials in pavilion designs expresses the importance of research that can contribute to the circular economy by helping to reduce the environmental impact of plastic waste.

6. Conclusion and Discussion

As a result, it is seen in the examples analyzed that the learning-by-doing approach allows students to explore their own ideas and experiment with different design approaches. Through collaboration and feedback with different disciplines, students learn to work effectively in teams. Through these studies, students gain important gains by conducting innovative and sustainable research with digital design and production tools. In this context, it is seen that the learning by doing approach is a valuable learning approach in architectural education, encourages creativity and innovation, provides students with practical experience and supports a holistic understanding of architecture.

It is very important to discuss “design-build” projects and experimental structures as a pedagogical approach in architectural education. This approach offers students the opportunity to transform theoretical knowledge into practice and develop their creative thinking skills. Design-and-build projects allow students to directly experience concepts related to architecture. In this way, students transfer theoretical knowledge into practice and develop their ability to solve real-world problems. In addition, the design and construction of experimental structures helps students develop their creative thinking processes. Students can come up with creative ideas because they have access to a variety of resources and construction methods. In this approach, which requires teamwork, students develop their communication skills by working together with experts from different disciplines and understand the importance of teamwork. However, mistakes may be encountered in the design-build process. Thus, students gain the experience of learning from mistakes. These projects also offer an important learning space for sustainability and material selection. Issues such as the use of recyclable materials, evaluation of environmental impacts, and innovative production techniques come to the fore in these projects. As a result, design-build projects and experimental structures encourage students' active participation in architectural education, develop their creative thinking skills and allow them to address important issues such as sustainability, recycling, innovative and advanced construction techniques. This approach supports students to both understand theoretical knowledge and translate it into practice. In this context, learning by doing makes the learning process more permanent as students experience the information. The experiences gained leave deeper traces in students' memory and the association of knowledge with real world applications helps students to better understand the subject.

Future work could focus on longitudinal studies to assess the impact of these practices on student outcomes, integration with digital tools, and sustainability measures. Such directions will not only strengthen academic contribution but also provide practical guidelines for educators in architecture and beyond.

Learning by doing is an approach to learning that focuses on students acquiring knowledge through concrete experiences. This approach encourages active student engagement and relates the meaning and significance of knowledge to real-world applications. In this context, project feasibility, programming, teamwork, communication and leadership can be expressed as advantages of learning by doing/experiencing from the pavilion studies carried out in architecture departments.

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