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A Comparative Assessment Towards the Use of Informal Education Buildings as a Tool in Sustainability Education: A Case Study of Türkiye

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Abstract

Aim: This study explores how sustainably designed informal education buildings can serve as tools for sustainability education, focusing on both architectural features and their integration into educational practices. It addresses a research gap in Türkiye by examining the hidden educational potential of such buildings through theoretical analysis and comparative evaluation with international best practices. Method: Selected buildings in Türkiye were assessed based on sustainable architectural design principles and their capacity to contribute to public education. These were compared with internationally recognized examples using five core sustainability criteria: site and transportation, water, energy, materials, and indoor environmental quality. Data collection included literature review, field visits, and semi-structured interviews. Findings: Four out of five main sustainability themes—site and transportation, water, energy, and materials—are relatively well integrated into educational uses in international examples. However, indoor environmental quality remains underutilized in both international and national contexts. In Türkiye, educational use is primarily limited to features related to energy and site planning. National examples also fall short in terms of training duration and instructional quality compared to their international counterparts. Conclusion: For informal educational buildings to function effectively as tools for sustainability education in Türkiye, early-stage design processes must intentionally incorporate educational strategies tied to environmental features. Emphasizing interdisciplinary collaboration and integrating educational theories into design can significantly enhance the impact and accessibility of sustainability education.

Keywords: *Architecture and learning, Buildings that teach, Informal environmental education, Sustainable design, Sustainability in Türkiye*

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INTRODUCTION

Sustainability is a broad concept encompassing environmental, economic, social, and cultural dimensions (United Nations, 1987; United Nations, 1992). However, studies have historically focused on its environmental and economic aspects, overlooking the social dimension—a gap addressed only in recent years.

In the building sector, sustainability is often reduced to energy and resource certification systems, neglecting its broader meaning and educational potential. This results in a public perception of sustainability as abstract and inaccessible. Architects are thus responsible for making sustainable design more tangible and communicative.

Sustainable buildings hold significant potential as educational tools that raise awareness through their physical features. The integration of sustainable design into school architecture and curricula has enhanced societal understanding of sustainability. However, learning is not limited to schools. The separation of "school" and "learning" is increasingly questioned due to the limitations of formal education in providing real-life experiences.

The idea that cognitive learning for sustainability is not confined to the formal curriculum is well-supported in the literature (Gramatakos & Lavau, 2019: 386) (Hopkinson et al., 2008; 435-454) (Lipscombe, 2008: 455-468). The concept of “using sustainable buildings as educational tools,” though often applied to schools, is also relevant to various building types. This approach transforms buildings into learning tools by embedding educational science into spatial design.

Out-of-school environments like museums, ecological centers, and botanical gardens offer motivational and experiential learning opportunities (Laçin Şimşek, 2011: 45; Adıgüzel, 2006: 32–41; Bozdoğan, 2011: 15). Informal education, characterized by unstructured, lifelong learning, adapts to the learner’s needs and contexts (Colardyn & Bjornavold, 2004: 69–89; Dip, 1987: 300–315).

UN conferences and reports emphasize education’s central role in achieving sustainability goals. The Stockholm Conference, Brundtland Report and Agenda 21 highlight the need for interdisciplinary, lifelong, and accessible sustainability education (United Nations, 1972, United Nations, 1987, United Nations, 1992). Meredith et al. (2000: 39) underline that environmental awareness must be nurtured continuously.

Globally, there is a growing trend of designing buildings that incorporate sustainability both socially and educationally. For such buildings to serve as effective educational tools, sustainability principles must be integrated into the early stages of design with pedagogical intent. This study reviews notable practices at the intersection of sustainability education and architecture.

LITERATURE REVIEW

UNESCO, as the specialized agency of the United Nations for education, is responsible for leading and coordinating the Education 2030 Agenda, a

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key component of the global movement to eradicate poverty through the achievement of the 17 Sustainable Development Goals (SDGs) by 2030. Education plays a central role in reaching all of these goals and is specifically addressed in Goal 4, which aims to “ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.” The Education 2030 Framework for Action serves as a roadmap for the implementation of this ambitious goal and its associated commitments.

In the Berlin Declaration on Education for Sustainable Development, published by the United Nations Educational, Scientific and Cultural Organization (UNESCO) within the scope of the "Education for Sustainable Development (ESD) for 2030" framework, it is emphasized that:

"Education for Sustainable Development (ESD) should be integrated into all levels of education and training — from early childhood to tertiary and adult education, including technical and vocational education and training (TVET) — as well as into non-formal and informal learning, ensuring that all individuals are provided with lifelong and life-wide learning opportunities for sustainable development” (UNESCO, 2022: 3).

According to Orr, whose studies examine the evolution between architecture and educational science, design and construction are not merely technical aspects—they reflect the broader worldview of a society. Buildings and landscapes carry implicit messages that can significantly influence learning (Orr, 1997: 597–600; Taylor, 2009: 59–60). Efficient sustainable design fosters a conscious, meaningful relationship between nature and humanity. It is about ethical, communicative interaction with users rather than simply adding solar panels or green roofs (Guarinello, 2005: 38).

Individuals interact with many buildings throughout different stages of their lives, experiencing diverse activities and emotions within them. A building thus becomes a dynamic participant in social and cultural life, offering various perspectives (Cole, 2014: 836–857). With its architectural design and the possibilities, it offers, a building possesses an active, vibrant, and variable structure—one that is deeply connected to, and influenced by, its location. It is in a constant state of change and transformation, adapting to shifting conditions (Arslan Avar, 2009: 9).

According to Priest, informal education—which is based on “learning by doing” and emphasizes the relationship between humans and nature:

- takes place both inside and outside the building,
- involves cognitive, emotional, and motor skills that appeal to various senses (sight, hearing, taste, touch, smell, and intuition),
- is interdisciplinary,
- considers human relationships at personal, ecosystemic, and broader environmental levels

(Priest, 1986: 13–15).

A key aspect of designing a building as an educational tool is to treat both its interior and exterior as a cohesive whole, shaped by

environmental data. Building service systems can be integrated into the curriculum—for example, students can observe and learn from the visibility of heating and cooling systems, or explore how electricity from renewable sources is generated as part of science or business lessons. Similarly, students can study solar movement and light-shadow patterns through window and eaves design.

This transformation requires collaboration among professionals from diverse fields—architects, educators, mechanical system designers, and clients. Through such cooperation, buildings shift from being passive to active educational agents. Their sustainable features become lesson materials and laboratories, turning the building into a living organism that communicates directly with users.

For this interaction to be successful, the architect must:

- understand the pedagogical and philosophical foundations of sustainability and environmental awareness,
- collaborate with other disciplines to create a curriculum based on these foundations,
- have knowledge of integrating system-monitoring elements into the building

(Jones, 2010: 83).

With this level of awareness, individuals can better understand environmental problems, evaluate possible solutions, and propose innovative ideas. Sustainability-focused educational activities help people develop a sense of responsibility, raise awareness about environmental issues, and apply this knowledge in everyday life.

AIMS and SCOPE of the STUDY

Comparative evaluation of the informal educational buildings with the sustainable architectural design features in Türkiye, in the framework of international pioneering examples, has been targeted in the study. It is intended to suggest recommendations for improving the use of national samples as a tool in sustainability education in the light of available data. The lead research questions of the study are as follows;

- Which building types currently carry the mission of presenting sustainability education informally to the community in the international and national environment?
- What kinds of methods are used for the purpose of using architecture/building as a tool to teach sustainability in informal educational buildings?
- What is the level of sustainable informal educational building examples aim to teach sustainability in Türkiye?
- What can be done to improve sustainable informal educational buildings examples in Türkiye in the context of "architecture's contribution to sustainability education"?

Though there is an absence of any studies to assess informal educational buildings serving with the mission to teach sustainability in Türkiye, it is hoped to raise awareness about the issue with such a study.

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Building types with different functions such as solar house, clean energy house, energy education center, waste, and energy museum and education center have been determined for the case study in Türkiye. It has been observed that only academic and/or research activities are carried out while community education is not included in some of the sample buildings. In the others, the concept of sustainability is included on an educational basis, but there is no use of architectural features as educational tools. Consequently, examples of buildings that are both designed with the sustainable architectural design approach and using these features in sustainability education at the same time are determined for the case study. The sampling is limited with seven buildings that meet the main parameters determined for the study. These buildings located in different cities in Türkiye, they function as a museum, training center, solar house and mixed. Despite the frequent occurrence of library examples included the sustainability education in the international stage, could not be reached the appropriate library example may be included in the study in Türkiye.

MATERIALS and METHOD

Methods and strategies identified in this study are as follows;

• Literature survey / Determination of case study

First of all, a comprehensive literature search was carried out and both the theoretical infrastructure and the sample buildings were examined. The parameters determined during the design of the study are shown in Figure 1;

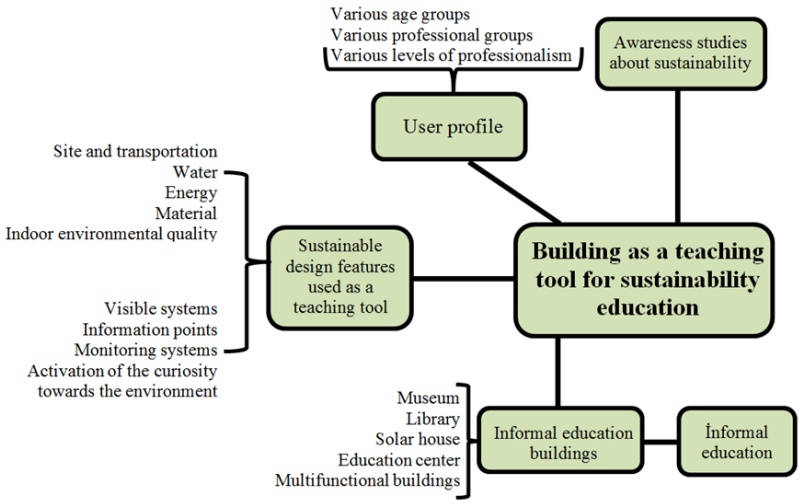

Figure 1. Parameters of teaching sustainability through architecture.

In the framework of criteria presented in Figure 1, successful international and national samples were determined (Figure 2 and 3). Information on the architectural characteristics, current statuses and use for sustainability education of all example buildings has been reached.

• Creation of building identification sheets

Sustainable architectural features of determined example buildings have been examined under five main titles (site and transport, water,

energy, material, interior environmental quality) (Table 3 and 4). On the other hand, the inclusion of sustainable building characteristics to the sustainability education has been questioned. In this respect, the introduction chart which combines the "sustainable design" title with the "education" title, has been created for all international and national examples included in the study (Table 5).

• Building visits and interviews with authorities

Building visits and interviews with authorities were held in order to gather information on the use and current status of the buildings. In addition to the national samples, the CAT (Center for Alternative Technology-UK) was also visited. A semi-structured interview method has been preferred in order to find innovative ideas that may arise during negotiations and inferences for future plans and programs [Merriam, 2013]. With the semi-structured interview method, the accuracy of the information obtained from the literature was confirmed and information was obtained from the authorities on the current status of the buildings and plans for the future.

• Visual Aids for Comparative Analysis

International and national samples have been transferred to the graphs utilizing all the data obtained within the framework of the identified main titles. Microsoft Excel program was used to produce graphics (see Figure 4-9).

CASE STUDY

While the main goal was to evaluate and develop national examples, successful and leading international examples were also identified and included in the study in order to be able to make a comparative assessment in the case study.

International Case Studies

Museums, libraries, education centers and mixed-use building types are used as tools to teach sustainability in the international case. Ten examples identified for the study are shown in Figure 2. The basic selection criterion for each sample is the successful implementation of sustainability education through the building. Descriptive information for these examples provided in Table 1.

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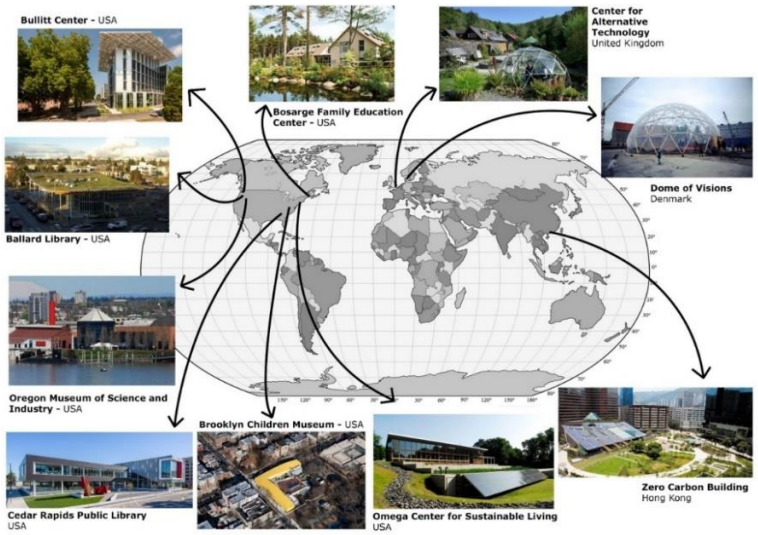

Figure 2. Location scheme of international informal education buildings

Table 1. Basic data of selected international buildings

BUILDING TYPE	BUILDING NAME	LOCATION	YEAR	AREA	FUNCTION
MUSEUM	Brooklyn Children Museum	USA	2008 (1899)	9500 m²	Museum, Cafe, Exhibition Area
	Oregon Museum of Science and Industry	USA	1992 (1944)	19710 m²	Museum
LIBRARY	Ballard Library	USA	2005	15000 m²	Library and Neighborhood Service
	Cedar Rapids Public Library	USA	2013	94000 m²	Library, Cafe, Auditorium
EDUCATION CENTER & SOLAR HOUSE	Omega Center for Sustainable Living	USA	2009	560 m²	Waste water Treatment Centre, education laboratory
	Dome of Visions	Denmark	2013	350 m²	Cultural Centre, Greenhouse
	Bosarge Family Education Centre	USA	2011	761 m²	Education Centre
	Centre for Alternative Technology	United Kingdom	1973	160.000 m²	Eco center
MIXED-USE	Bullitt Center	USA	2013	4800 m²	Office
	Zero Carbon Building	Hong Kong	2012	14700 m²	Office, Home, Exhibition Area

National Informal Education Buildings Used as a Tool in Sustainability Education

The use of some museums, solar houses and mixed-use buildings have sustainable features as a teaching tool for sustainability in Türkiye were analyzed in line with the purpose of this study. It has been researched whether the selected buildings use these potentials adequately. Due to development of the building samples constructed with this purpose and actively used only in recent years in Türkiye, the size of the search universe is already quite-limited. The seven sample buildings and their locations are shown in Figure 3. Descriptive information for these examples provided in Table 2.

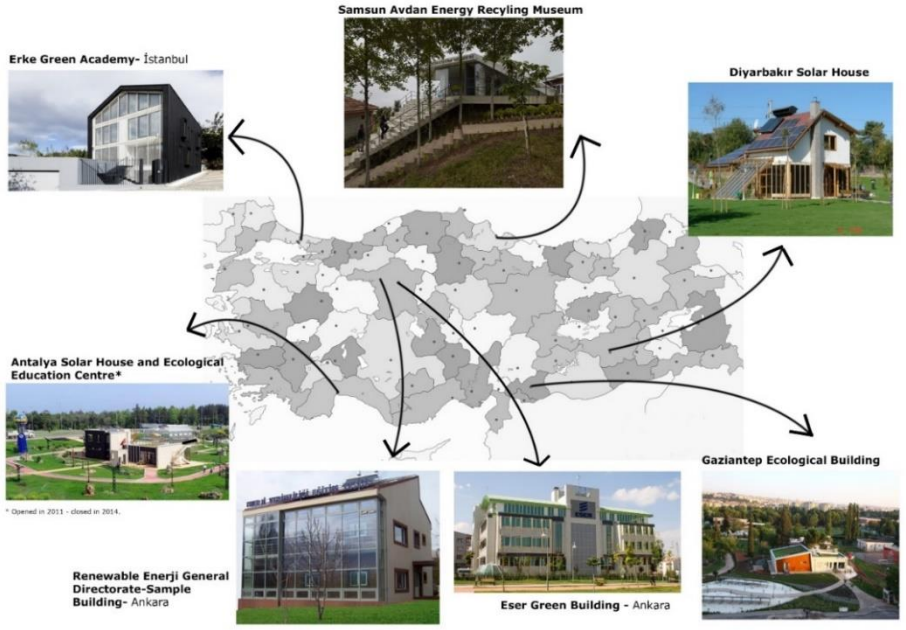

Figure 3. Location scheme of determined national informal education building examples

Table 2. Basic data of selected national buildings

BUILDING TYPE	BUILDING NAME	LOCATION	YEAR	AREA	FUNCTION
MUSEUM	Samsun Avdan Energy Recycling Museum	Samsun	2015	810 m²	Visitor center, museum
EDUCATION CENTER & SOLAR HOUSE	Antalya Solar House and Ecological Education Centre	Antalya	2010	10000 m²	Eco-center and solar park
	Gaziantep Ecological Building	Gaziantep	2013	325 m²	Conference hall, exhibition space
	Diyarbakır Solar House	Diyarbakır	2008	120 m²	Solar House
	Renewable Energy General Directorate-Sample Building	Ankara	2006	275 m²	Education Centre
MIXED-USE	Erke Green Academy	İstanbul	2013 (1980)	400 m²	Office and Education Centre
	Eser Green Building	Ankara	2010	7500 m²	Office

FINDINGS and DISCUSSION

The study focuses on the use of international and national building examples as educational tools and innovative approaches and methods for this use. In international case, informal sustainability education has spread to the buildings with various functions such as museum, library, solar house, training center and mixed-use. Both international and national examples - except for the two examples - were built after the 2000s. When area-based comparisons are made, it is seen that international samples are generally spread over a much wider area (most of which is more than 10,000 m2). Most of the national samples are small-scale, experimental ones under 1000 m2. The sustainable architectural design features of international and national informal education buildings are presented in Table 3 and Table 4. Table 5 illustrates how

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these features are utilized as tools for sustainability education and integrated into educational activities.

Table 3 shows how the concept of sustainability can be embodied through architectural design and conveyed to visitors. Most notably, many systems function not only to improve building performance but also as educational tools. Energy and water topics in particular are successful in translating theoretical knowledge into practice in international examples.

Table 3. Key sustainable design elements observed in selected international buildings

Sustainable Design Topics \ Building Example			Museum		Library		Solar House & Education Center				Multi-use Building	
			Brooklyn Children's Museum-BCM	Oregon Museum of Science and Industry-OMSI	Ballard Library	Cedar Rapids Public Library	Omega Center for Sustainable Living	Dome of Visions	Bosarge Family Education Centre	Centre for Alternative Technology – CAT	Bullitt Center	Zero Carbon Building-ZCB
Site and Transportation	Site selection									All mechanical equipment of the rail system is directly visible. The lakes that supply water to the system are used as landscape elements.	There is no private car parking lot. There are changing rooms and showers to support bicycle transportation.	
	Transportation									In order to compare the efficiency of using compost and manure in different combinations with slate stone, cultivated gardens were arranged.		
	Native landscaping and ecosystem protection			Information boards are used to explain how the "Rainwater Ditches" system works, why it is environmentally friendly and why it is important.						Every system and structure used in open space is part of sustainability education.		
	Outdoor classroom				The green roof can be observed by climate and ecology working groups and visitors. The green roof can also be observed through a periscope mounted on the wall near the book borrowing desk. In addition, the development of the plants on the green roof is constantly monitored and their adaptation to the conditions and their productivity are recorded.	The green roof of the building is open to visitors and used for social events. There are information boards about the use and benefits of the green roof.				As an alternative to agriculturally inefficient slate-covered land, fertile areas for agriculture are obtained with different fertilizer and compost components. Sample gardens are located side by side to compare these areas and observe their yields.		
	Landscape				The amount of water collected and consumed is presented to the visitors on the LED screen.	Cisterns and solar panels on the green roof can be observed by visitors. There are information panels about these systems.	Rainwater collected from the roof is transmitted to the fountain at the entrance of the building to make visitors feel the water acoustically and sensually. People feel the effect of water at the entrance of the building.			The collection of rainwater and its transfer to groundwater can be observed by visitors. Visitors can also observe the treatment of the water collected in the pools in the water source area.	The rainwater collection and treatment systems of the building can be examined by the visitors.	
Water	Storm water		With the water station, which includes questions such as "How much water is wasted by flushing the toilet?" and principles of water conservation, children learn about water conservation and use.			Current and past water usage data of the building is monitored on the LED screen located at the entrance of the building.			Water usage data is presented to visitors through the monitoring screen.	The water-balanced rail system, which moves with the power of water energy, transfers the water supplied from the upper level to the ponds in the center by gravity and from there it is stored in the lower chamber of the rail system wagons and descends to the lower level by gravity.	The luminaires used can be observed by visitors.	
	Conservation and monitoring						The biological pond inside the building can be observed by visitors. Visitors are informed about the working principle of the biological pond; gray and black water.			There are warnings that personal products used by people staying at the facility should contain ingredients that are not harmful to the environment. The consequences of this situation in the water supply and treatment system are detailed in each room.	The gray water treatment systems of the building can be examined by the visitors.	
	Waste water	Grey water					The stages until the water from the toilets is treated and transmitted underground are described schematically around the biological pond.			The tanks and processes of the waste accumulated for fertilizer can be observed.		
		Black water										The systems used for lighting and ventilation and their functioning are clearly visible throughout the building.
Energy	Total performance	Lighting										
		Ventilation		Information boards are used to explain how the heating, cooling system works, why it is environmentally friendly and why it is important.				The building is a center where mostly social events are organized and people from different disciplines come together. Due to its innovative solutions, visitors can experience the building and learn about its different features.		Different examples such as rammed earth walls, the use of skylights and heat pumps are illustrated with diagrams of the buildings in which they are used. In addition, the systems are not hidden but directly visible and can be examined by visitors.		
		Heating	Geothermal system elements are painted in bright colors to make them interesting. In addition, the working principle of geothermal energy, the movement of water from the earth and its use as an energy source, is explained with electronic panels and diagrams.									
		Cooling	The solar panels on the facade and roof are visible. Thus, they attract the attention of visitors. In addition, the layout principles and functions of the panels are explained to the visitors with information boards.		Electric energy data generated from solar energy is transmitted to visitors with indicators placed on the window sills. In addition, all energy data of the building is monitored and presented to visitors on the LED screen.		Solar panels in the landscape used for electricity generation are not hidden and used as design elements.		The solar panels on the south façade of the building can be perceived in the parking lot area. In this way, the building conveys its sustainable features to the visitors.	Eco cabins accommodate groups or families visiting the center in groups. In this way, the impact of the items used in daily life and the behaviors applied on the environment are understood. In order to observe the energy provided by the solar panels and the conditions under which the panels produce energy, there are monitoring boards and information texts opposite the panels.	In a region like Seattle, where the number of sunny days is very low, the construction of a building that provides all its energy from the sun (zero energy) is exemplary. Visitors and employees using the building can monitor the energy production and consumption data of the building.	
	Renewable energy			With the use of weight principle elevator, low-energy and environmentally friendly weight principle elevator is used instead of hydraulic elevator system requirements. There are information boards about the working principle of the elevator. These panels explain how the system works, why it is environmentally friendly and why it is important.						The passive design features and energy use relations of the buildings are conveyed to the visitors within the framework of trainings.		The data provided on energy conservation are transferred to the tracking screen in the input area in 3D and graphically. These data are analyzed under five main headings: energy, layout, indoor quality, materials and water.
	Conservation					Current and past energy data of the building is monitored on the LED screen located at the entrance of the building.			With the Truth Wall, a region on the wall is made transparent, showing layers of insulation.	Sample buildings can be examined comparatively. In addition, a section of the wall of the consultation building is made transparent to show the sheep wool used for insulation.		
	Insulation									Six different joint details of timber column-beam systems are observed in sample building. While visitors observe the different details, architecture students work		

									on and build this structure in certain periods.			
Material	Local materials	The materials used throughout the building are introduced to the visitors. The methods by which they are recycled and their uses are explained. In addition, the fact that bamboo is a fast-growing plant and that it is therefore chosen as a flooring material instead of wood is expressed with information boards.	Through the use of recycled and recyclable materials, awareness of sustainability is raised and information is provided on the techniques of obtaining these materials, their use in daily life and their production.						The material properties of the buildings are presented to visitors on information boards or during building tours.			
	Reuse, recycled and recyclable material usage						Bringing together the use of innovative materials, architectural design and sustainability, the building hosts different events and interacts with the people of the region.	Data on the materials used are presented to visitors through the tracking screen.	Photographs and explanations of the sources of the materials used, such as hemp fiber, compressed soil, wood, perlite and cork, and the stages of their use in the building are included together with material samples.	The source and content information of the materials used are shared with the visitors. In addition, the materials used in the interior are not hidden but openly exhibited, and their fasteners and carrier elements are observed.	The selection criteria for materials, their use and their impact on daily life are explained to visitors.
	Specific sustainable material selection criteria											
	Waste material control											
Indoor Env. Quality	VOC											
	Thermal comfort											
	Daylighting											
	Views											

According to Table 4; energy is the most commonly and successfully used topic in the examples in Türkiye. Topics such as water, materials and indoor environmental quality are both poorly integrated in terms of architecture and are not used in terms of education.

Table 4. Key sustainable design elements observed in selected national buildings

Sustainable Design Topics \ Building Example			Museum	Solar House & Education Centre				Multi-use Building	
			Samsun Avdan Energy Recycling Museum	Antalya Solar House and Ecological Education Centre	Gaziantep Ecological Building	Diyarbakır Solar House	Renewable Energy General Directorate- Sample Building	Erke Green Academy	Eser Green Building
Site and Transportation	Site selection		Within the structure in the landfill site, the theoretically explained issues can be directly observed in the field.	With the establishment of the center, the region was brought to the city.					
	Transportation							There is no private car parking lot. There are changing rooms and showers for those who reach the building by bicycle. In this way, bicycle transportation is supported.	
	Native landscaping and								
	Outdoor classroom			At the end of the building tour, tomatoes grown in the greenhouse are tasted by the visitors. Thus, visitors are shown that agriculture can be practiced with innovative methods other than traditional agriculture.					There are examples of systems used to obtain energy from alternative energy sources such as solar, water and wind, and explanations of these systems. In this way, the impact of sustainability can be observed not only within the building but also in the use of outdoor spaces.
	Landscape								
Water	Storm water								
	Conservation and monitoring								
	Waste water	Grey water						The gray water treatment system can be observed in the parking lot.	
		Black water							
Energy	Total performance	Lighting							With the system, which is first explained theoretically, the building can be observed by visitors on a tour and its functioning can be examined. Experiencing that sustainable design features are not always used with the same efficiency, the users organize a joint study with TÜBİTAK and set up a meteorological station that enables the automation system of the building to be updated instantly, monitors instant humidity, temperature, daylight data and transfers these data to the systems inside the building.
		Ventilation							
		Heating			Canadian well air intakes are observed from outside the building with solar panels.	The green pipes used for cooling the building on the ceilings are left exposed and therefore can be observed.	The effect of the Trombe wall on passive heating is observed by the visitors. Innovative solutions for heating and cooling the interior space are observed with the exemplary wall system in which ground source energy and wall system are used together.		
		Cooling							
	Renewable energy			Examples of innovative methods such as solar trees used in the open space and sports equipment that generate electricity with human energy can be examined by visitors. In addition, the control center of the building's systems has been made transparent and open to the observation of visitors.	Solar panels in the garden and on the roof are made visible. The energy produced and consumed data is transferred to the visitors through the automation system.	Solar panels on the roof and in the garden are easily visible. It is experienced that daily needs can be met thanks to the energy produced by alternative methods.		The amount of energy produced and consumed is monitored instantaneously and recorded to create an academic data bank.	
	Conservation								
	Insulation					In order to observe different results in roof insulation, free perlite was used in one part and clay and reed from traditional Anatolian houses were used in the other part.			
Material	Local materials								
	Reuse, recycled and recyclable material usage								
	Specific sustainable material selection criteria								
	Waste material control		Examples for the reuse and recycling of construction and structural waste are located within the building. The transformation stages and the process are conveyed to the visitors with examples in the building.						
Indoor Env. Quality	VOC								
	Thermal comfort								
	Daylighting								
	Views		Completely surrounded by glass, the structure allows the subject of transformation, which is explained in the museum with presentations and examples, to be observed throughout the landfill. Due to its location and design, the structure formed by the bending of different surfaces provides viewpoints to different points of the landfill.						

As seen in Table 5, it is observed that 4 of the 5 main headings (site and transport, water, energy and material) in international cases are reflected in a relatively balanced manner in educational use. It is noteworthy to see the finding that shows that only sustainable features of indoor quality don't reflect educational use in both international and national contexts. Sustainable features that are used as educational tools within national examples are concentrated around energy and site and transport

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headings. Sustainable features, including indoor environmental quality, water and materials cannot adequately support education.

Table 5. A comparative analysis of sustainable architectural elements in buildings

Building Example / Sustainable Design Topics			**X** -- Sustainable Architecture Design Topics Used As Teaching Tool										**O** -- Sustainable Architecture Design Topics						
			International Building Examples										**National Building Examples**						
			Museum		Library		Solar House & Education Centre			Multi-use Building			Museum	Solar House & Education Centre			Multi-use Building		
			Brooklyn Children Museum-BCM	Oregon Museum of Science and Industry	Ballard Library	Cedar Rapids Public Library	Omega Center for Sustainable Living	Dome of Visions	Bosarge Family Education Center in Coastal Maine	Centre For Alternative Technology-CAT	Bullitt Center	Zero Carbon Building - ZCB	Samsun Avdan Energy Recycling Museum	Antalya Solar House and	Diyarbakır Solar House	Gaziantep Ecological Building	Renewable Energy General Directorate-Sample Building	Erke Green Academy	Eser Green Building
Site and Transportation	Site Selection			X			X	X	X	O			O	O	X				
	Transportation				X					O	O			X	X	X		O	X
	Native landscaping and ecosystem protection		X	X	X		X		X	O		X		X					
	Outdoor classroom			O						O	X	X		O	X	X			O
	Landscape				O	O			X	O		X			X			X	X
Water	Storm Water				O	O	O		X	X	O	X		X	X	X		X	X
	Conservation and monitoring		O		X	O			O	O	O								X
	Waste Water	Grey Water					O			O	O	X			X	X		O	X
		Black water					O			O	X	X			X	X			
Energy	Total Performance	Lighting	X		X	X			X		X	O	X			X	X	X	O
		Ventilation	X		X		X		X			O	X		X	X		X	
		Heating	O	O			X	O	X	O	X			X	X	O	O	X	O
		Cooling	O	O			X	O	X	O	X	X		X	O	O	O	X	O
	Renewable Energy		O		O				O	O	O	X		O	O	O	X	O	X
	Conservation			O		O	X			O	X	O				X			
	Insulation				X		X	X	O	O				X	O		X	X	X
Material	Local materials						X		X	O								X	
	Reuse, recycled and recyclable material usage		O	O	X		X	X		O	X			X				X	
	Specific sustainable material selection criteria				O		X	O	O	O		O	X		X				X
	Waste Material Control						X			X			O						
In. E. Q.	VOC		X				X	X			X								X
	Thermal Comfort														X				
	Daylighting		X								X	X						X	X
	Views					X							O						

Available sustainable features of international buildings are transferred to visitors through daily and weekly building tours and practical training programs. Thus, visitors have both theoretical knowledge about the subjects and experience in the systems in practice. There are also examples of international centers spread over a wide site area and offering accommodation. The area where the building is located is becoming a center of attraction. Individuals can learn by seeing, touching, understanding and experimenting the sustainable features in these public buildings and transfer information to their daily lives.

Sustainability education addressed within the presentation; for introduction of the systems and building tours in the examples of Türkiye; often do not offer the opportunity of observation, experimentation and comparison. Teaching sustainability is already open to development in Türkiye due to problems such as financial difficulties, lack of enough awareness, the issue of sustainability mostly covered within the framework of certification systems, the inability to assess owned features due to the lack of a relationship between the current function of the building and sustainability education, the lack of enough site area and inability to assess and etc. Addressed visitor profile mostly consists of elementary school, junior high school or high school students. Adequate awareness and effort hasn't yet been given to the possibility for people to observe, experiment, compare the systems and find innovative solutions. Table 6 shows the main differences in the scope and

functioning of sustainability education between the examples of international and national informal education buildings.

Table 6. The main differences between national and international examples

Sustainability Education	International Informal Education Buildings	National Informal Education Buildings
Type of buildings	Museum, library, solar house, education center, multifunctional buildings	Museum, solar house, education center, multifunctional buildings
User profile	For all ages and for all professional levels	For mostly primary and high school students
Design	The architecture of buildings reflects their sustainable properties which they have and they are also interesting for their zone.	The buildings except solar houses could not reflect their sustainable properties and they could not be different at their zone.
Used sustainable design titles	Site and transportation, water, energy, material	Site and transportation, energy
Education period	Daily and weekly educations-building tours	Hourly building tours

It would be beneficial to examine each of the sample buildings within the scope of the study individually in the context of each sustainability topic. It is assumed that each criterion in the graphs is equivalent. In the frame of sustainable design topics, findings shown in blue indicate the potential sustainable features that can be used for education; while the red ones indicate the sustainable features that are already integrated with education (see Figure 4-9).

Site and transportation

Sustainability education will not be restricted only to the indoor space; it is well known that educational use of open areas, studies carried out for the protection of plant and animal species and transportation issues are also carrying a high educational potential. The sustainable design features of international and national examples in the context of the site and transport and the situations in which these features are presented to visitors as educational tools are shown in Figure 4.

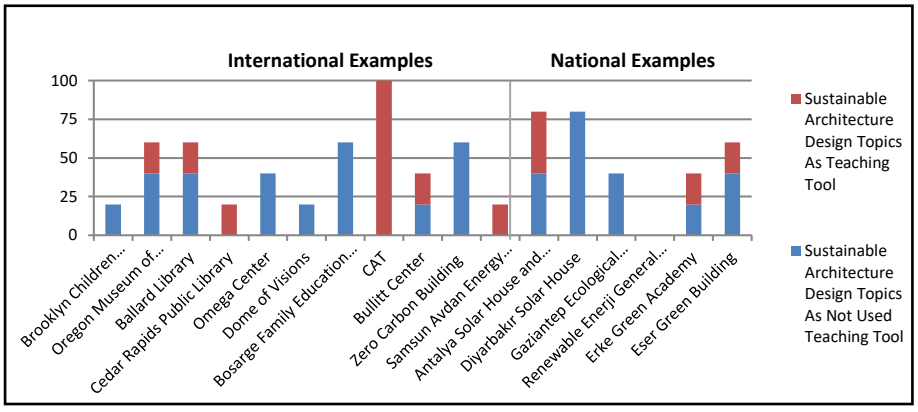

Figure 4. Sustainable design topics of international/national buildings on the scope of "site and transportation" and the usage of these topics as a teaching tool

According to Fig. 4, four out of the ten international samples in sustainability education does not benefit from the sustainable site and transportation characteristics, the four samples are also fairly partially

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utilized. It is seen that both site and transportation principals are available and each one is utilized as an educational tool in the Center for Alternative Technology (CAT).

Remarkable features of the international examples included in the case study are as follows;

- The use of industrial areas and/or brownfields for the community benefit,
- The use of bio swales which meets the need for irrigation of existing green areas, protect the natural vegetation, allows to be transmit clean water to the main water sources through the purification process - information boards containing the working principle and the environmental-friendly features of the bio swales,
- Easily accessible location by public transport, bicycle and/or on foot, no private car parking. Lockers and showers to support cycling access,
- The use of a green roof which is a sustainable roof system. For site inspection of the roof by visitors, observation from inside of the building with the periscope is possible. Recording the usage data of the roof. Information boards on the use and benefits of the green roof,
- Agricultural areas arranged in open areas of the building. Side-by-side gardens aiming to compare the yields of compost and fertilizer,
- Being every system and building used in open space a part of sustainability education.

Considering the examples of Türkiye, the table is similar. It has been shown that they don't benefit sufficiently from the available sustainable site and transport properties. Due to the fact that Samsun Avdan Recycling Museum exhibits the recycling process occur on the ground that takes place on, it is being used as an educational tool within the scope of "site and transportation" title. While Antalya Solar House, Erke Green Academy and Eser Green Building use some of the features they have as education tools, they have some potential features not yet been equipped with education functions. Although Diyarbakır Solar House and Gaziantep Eco Building have sustainable features within the title of site and transportation, these properties are not currently used as educational tools.

Water

It is observed that international examples widely and effectively benefit from architectural design features they have on the reuse of the wastewater, rainwater use and water conservation topics. As an ideal example of a wastewater treatment center; the "Omega Center for Sustainable Living" implements a wide range of methods to keep visitors informed about water treatment and conservation. (Figure 5)

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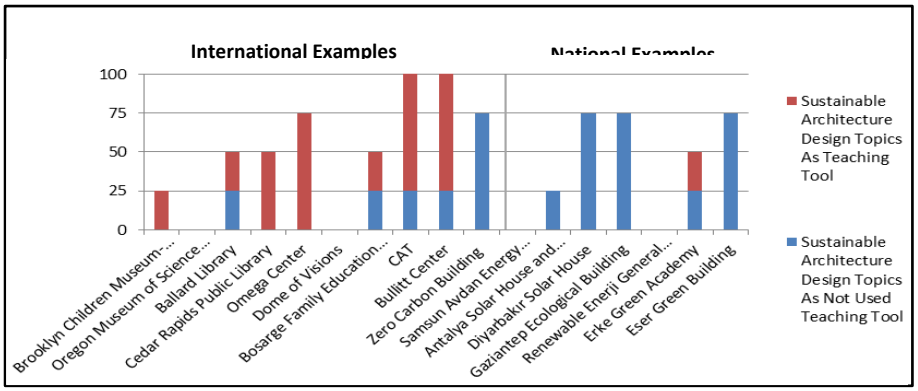

Figure 5. Sustainable design topics of international/national buildings on the scope of "water" and the usage of these topics as a teaching tool and transportation" and the usage of these topics as a teaching tool

International examples include a variety of positive features in the context of water efficiency, and able to reflect many of them to educational use. Some remarkable features are;

- Local plant selection without irrigation, water conserving plumbing equipment,
- Water station area where water conservation principles are described,
- Usage in various forms of the water obtained from the green roof and transferred to cisterns. Providing the energy required for irrigation with solar panels on the cisterns. All these systems are observable by the visitors. Recording the amount of water collected and spent in these systems and to present it to the visitors via the follow-up screen,
- The use of water treated in various forms by creating a biological pond within or outside the building, be able to be observed of the working principle of the pond by the visitors,
- Purification of rainwater by collecting and usage throughout the building. The collection areas of the rain waters, the process of purification and their transfer to underground waters can be observed by the visitors,
- Available warnings about the personal items used by visitors should be in non-environmentally harmful content in accommodation units. (?) Detailed presentation of the results that this situation cause in the water source and the treatment system in each unit,
- Gray and black water treatment throughout the building and use in appropriate functions. of Gray water treatment systems and tanks with stored waste for fertilizer purposes can be observed by the visitors.

National examples need to be developed both in terms of an architectural design standpoint and the transformation of the building into an educational tool about water conservation. Sustainable properties are not observed in Samsun Avdan Recycling Museum and General Directorate of Renewable Energy-Sample building in the scope of water efficiency. The other five examples have potential features that could be an educational tool in teaching sustainable water consumption.

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Especially Diyarbakır Solar House, Gaziantep Ecological Building and Eser Green Building have high potentials.

Energy

"Energy" is the design topic which has more architectural design features compared to other sustainable design topics and the most common use of these features as educational tools in international and national buildings. This situation is striking in all cases except "Samsun Avdan Recycling Museum" which focuses specifically on waste recycling and "Omega Center for Sustainable Living" which focuses on water conservation. (Figure 6)

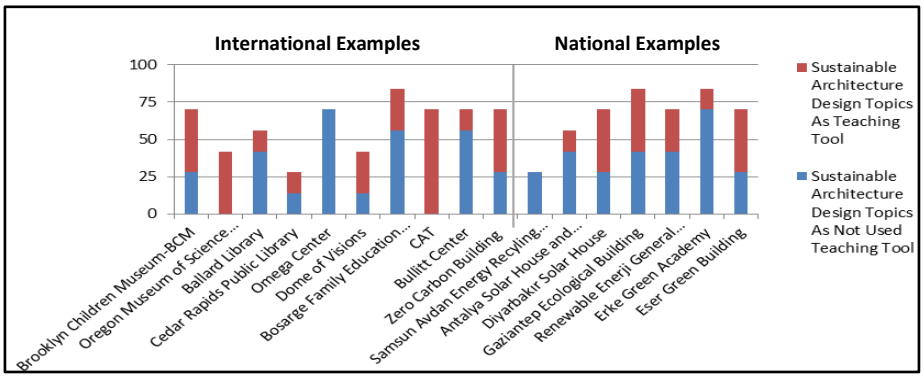

Figure 6. Sustainable design topics of international/national buildings on the scope of "energy" and the usage of these topics as a teaching tool

The remarkable energy conservation characteristics of the international examples and their educational use patterns are as follows;

- All passive and active energy systems used throughout the building can be observed, made interesting and informative by the visitors,
- Describing the relationships between the passive design features to reduce energy use of buildings and energy use to visitors through various trainings,
- The current and past energy data of the building can be traceable through the LED display at the entrance of the building. Presenting data of the electric energy generated from the solar energy to visitors through the indicators located on the windowsills. The use of the solar panels in the landscape as a design element without being hidden. Follow-up panels and informational boards near the solar panels in order to observe the energy provided by the solar panels and the conditions which the panels generate energy under,
- Making attractive the sustainable system components like geothermal heat pumps, air-to-air, air-to-water heat pumps, cooling towers, etc. used for heating-cooling by painting with bright colors. Explanation of working principles through electronic boards and schemes,

- Provision of visibility of the solar panels on the facade and roof. Explanation of the layout principles and the functions of the panels with the information boards to the visitors,
- Showing the insulation layers by making a certain part of the wall surface transparent,
- Explanation of applications like compressed soil wall, ceiling windows, heat pumps and etc. in which building they are used through schemes,
- Design of zero-energy accommodation buildings in order to be able to grasped the environmental effects of the consumption habits adopted in everyday life by individuals, the presentation of life experiences in these buildings to visitors,
- Implementing different systems and methods on the buildings and presenting their performances comparatively to the visitors.

National examples except the Samsun Avdan Recycling Museum use a certain part of their characteristics on the energy efficiency for education purposes. In national and international cases, systems for renewable energy sources which are used to meet the heating and cooling needs, are often utilized in educational context. However, innovative solutions such as tracking of energy generation-consumption quantities, reduction of available energy use (OMSI eco-vator, CAT water-based rail system and etc.) in the international examples are not yet available within national examples.

Material

It has been observed that the selection of sustainable materials and the effort to transfer these characteristics to visitors in international cases are much more advanced than national examples (Figure 7).

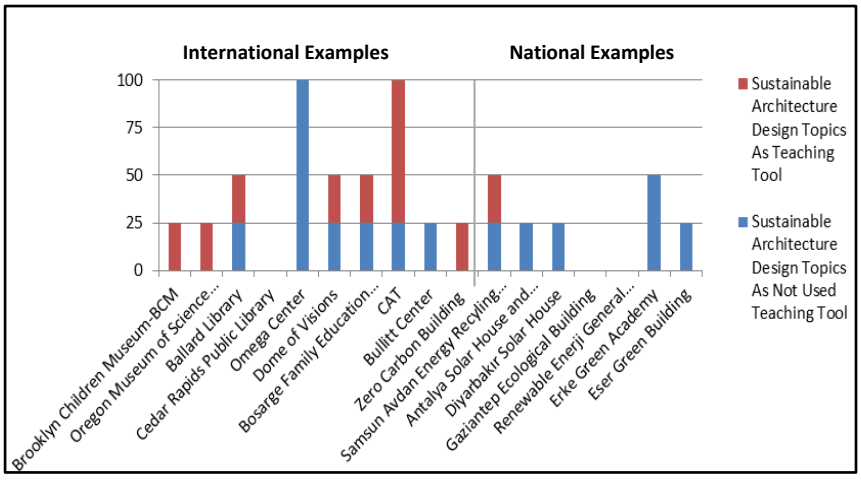

Figure 7. Sustainable design topics of international/national buildings on the scope of "material" and the usage of these topics as a teaching tool

The remarkable characteristics of the material efficiency of the international examples and their educational usage patterns are as follows;

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- Selection of materials with the properties of recycled/recyclable/low carbon content/local material used throughout the building. Informing visitors about the acquisition techniques, everyday use and the productions of these materials. The presentation of the resource and content information, selection criteria, usage and daily life effects of the used materials to the visitors through the screens during the building tours,
- Displaying the materials used in the interiors clearly without being hidden, to be observable of the connecting elements and the structural elements,
- To be observable of local materials and construction methods by the usage in different ways in the building in order to show the visitors different details.

Because of the sufficient awareness and lack of the principles such as the use of local materials, materials with recycled-recyclable content, waste management caused by material use in under the heading "material" in national examples, yet the usage of these criteria are limited both in the context of sustainability and as an educational tool. Material efficiency property used for design and education purposes is not observed in Gaziantep Ecological Building and Renewable Energy General Directorate Example Building. Characteristics of material use and recycling are rather limited in other national cases.

Indoor environmental quality

Sustainable architectural features about indoor air quality, thermal/visual/audio comfort and lighting/ventilation topics were almost not used in sustainability education in any international and national examples. (Figure 8)

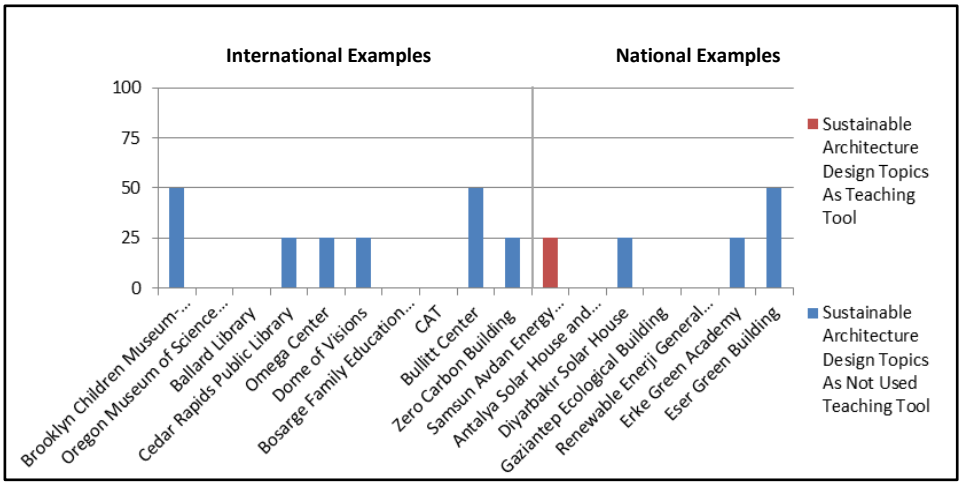

Figure 8. Sustainable design topics of international/national buildings on the scope of "indoor environmental quality" and the usage of these topics as a teaching tool

Remarkable features on the indoor environmental quality (but not integrate educational use) of international examples are as follows;

- The change of the city according to the seasons can be watched by the users by creating different points of views to the city on the buildings,
- The use of plant species that increase the amount of O2 while reducing the impact of CO2 and other harmful gases in the interiors,
- Measuring of temperature, humidity, lighting, CO2 and pressure data with sensors placed at different points of the building,
- Utilizing from the daylight in the interior at most with the use of high ceiling and large window surfaces. Determination of the locations of the eaves, skylights, roof windows and the solar tubes as a result of the daylight modeling.
- All these approaches and systems are made visible, observable and transferring to visitors.

Due to Samsun Avdan Recycling Museum being also aimed to exhibit the waste recycling area in which it is located, there is an effective use of the view in the context of serving sustainability education. The exhibition surfaces are gathered in the center of the building. Thus, there is the possibility of circulation around the building. Building which is entirely surrounded by glass; provides the observation of the recycling process described and examples in the museum throughout the solid waste field. Building is designed by bending of different surfaces and its location provides the points of view to the different points of the waste field.

Improvement Recommendations on National Examples

Studies towards the experimental buildings getting the mission to teach sustainability to community began to be developed after year 2000 and still continues in Türkiye. In this context, it is important to evaluate these buildings in this framework and carry out improvement works in order to put into potential features that can be used as educational tools from passive to active status. Each national sample was evaluated in the context of sustainable design topics. (Figure 9)

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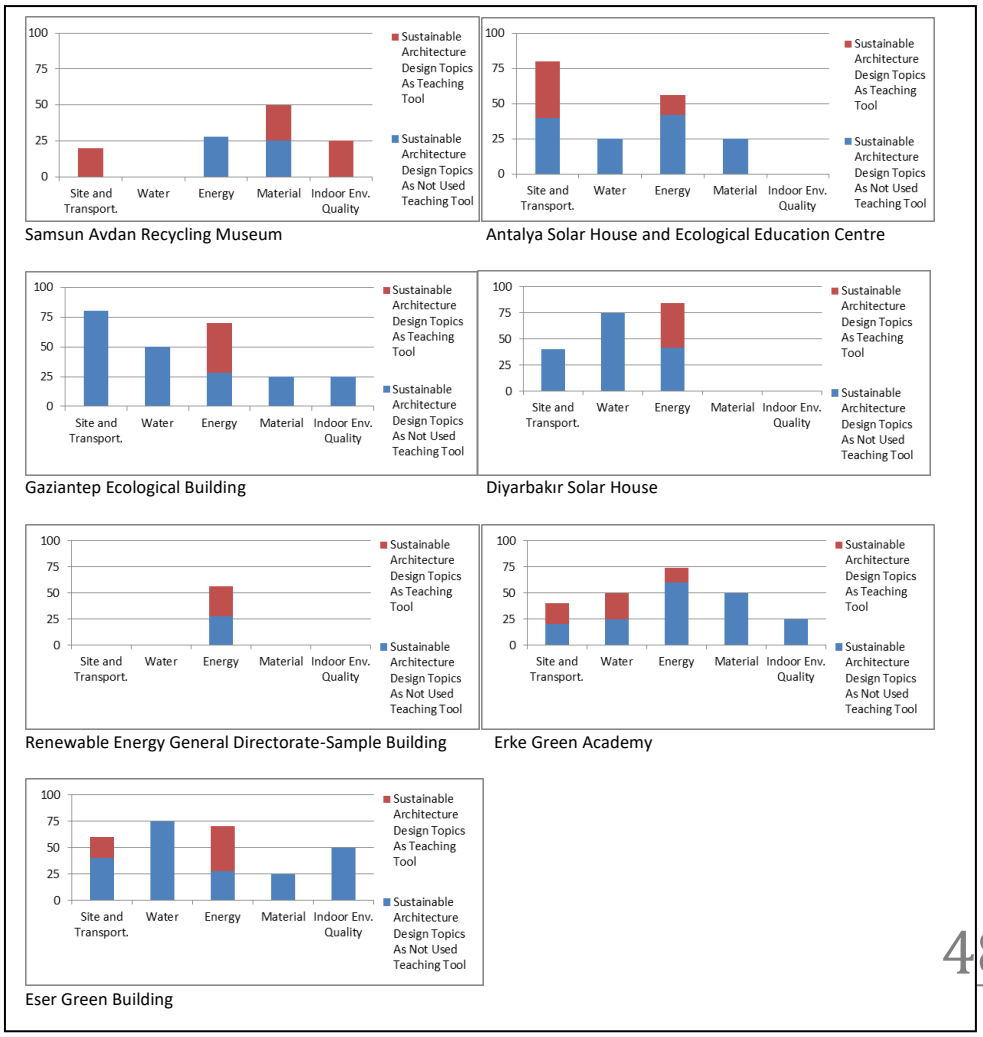

Figure 9. National Samples' features within the scope of sustainable design topics use for educational purposes

In the direction of the data presented in figure 9, the recommendations for the improvement of the national examples can be listed as follows;

While the traceability features of the land are utilized educationally in architectural design of Samsun Avdan Recycling Museum, there is no sensitivity to water efficiency. It has the potential features to be used for the purpose of sustainability education on energy and material topics (Figure 9). Creating outdoor walking/training routes that will allow monitoring the solid waste recycling process that takes place in the field as closely as possible can enrich the training mission of the building. The use of accumulated rainwater and its visualization to visitors are features that can be included in sustainable design. The building has passive features on daylight and ventilation with fringe and vented window design. These features can be passed on to visitors. In addition, solar panels that can be integrated can support the electricity needs consumed in the museum as well as informing visitors about renewable energy sources and energy conservation. Besides the information on the use of different material wastes and transformation methods are provided, it is possible to inform the visitors about why only concrete was used in the building, the positive and negative aspects of the construction. Facade and covering materials which can be transformed from different types of

waste can be introduced by applying for sample purpose in certain sections of the structure.

In addition to the sustainable features used for education in site and transportation and energy issues of Antalya Solar House and Ecological Education Center; there are different features that can be installed in the education function, improvement studies should be carried out especially in the context of indoor environmental quality (Figure 9). Observations and comparisons can be made to grow different plant species in different seasons on the green roof. Certain parts of the cistern system where the rainwater is deposited can be made visible. How the green roof provides insulation, positive and negative aspects can be examined together with the visitors and discussed by mutual question-and-answer method. Information on the concept of embodied energy, the recycling characteristics of materials used during construction and the presentation of sample materials can be given.

Diyarbakır Solar House has focused solely on the topic of "energy" and has only been able to integrate this title to education. However, it is an example of potential structural features that can be used educationally in all sustainability issues (Figure 9). The solar house uses its features as educational tools in the areas of insulation, the use of renewable energy sources, heating and cooling. The working principles, usage and structural characteristics of the Venturi chimney and wind catcher can be combined with open space usage. The building can express itself with the use of information boards and operating schedules in the open spaces at the points of observation of the available innovative systems. Building's potential features can be actively used by transferring the selection criteria of the building site and plant species can be used around the building in order to prevent overheating of the visitors. Tracking the data on the collection of rainwater, amount of water consumed and places of consumption and sharing with the visitors is important in terms of using the building more functionally. The basic characteristic of the building on the material topic is using the wood clearly. In this context, it is possible to establish sample systems which include comparison of wood with different building materials and address the touching and visual senses of the visitors by making use of different construction techniques, combination details and materials in certain parts of the building for comparison.

Gaziantep Ecological Building has sustainable design features that can be used for education in site and transportation, water and energy topics. However, currently only design features like renewable energy sources, heating and cooling are used for education purposes. Material and interior environmental quality is completely neglected in the design process (Figure 9). Sustainable system components such as solar panels, air chimneys and green roofs are observed outside the building. Location of information boards includes the features and the operational principals of these systems at appropriate points, can also provide a better understanding of the systems. The existing sensitivities like

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rainwater use, tracking of water conservation, reuse of waste water can be integrated into education by methods such as making the treatment systems visible, monitoring rainwater accumulation and utilization data. For example, the use of light and sound in different colors for the amount of accumulated rainwater can be reflected in the interior of the building. The building presents its features such as renewable energy, heat pump etc. through the models. In addition to this method, it will be beneficial to make certain insulation and joint points transparent on the building.

Renewable Energy General Directorate-Sample Building does not already have potential features that can be integrated to education in site and transportation, water, material and interior environmental quality titles. Features in terms of energy are often passed on to visitors via sample systems called training units (except Trombe Wall and greenhouse use), Most of all, the building needs to be improved in terms of sustainable architectural design (Figure 9). The building will be self-explanatory by using the sample systems that are exhibited independently in the structure as a component in the appropriate parts of the structure. For example, instead of the sample glass unit used to sense the insulation difference between single and double glazing in the structure, it is possible to obtain a much more educative result by replacing the glazes in a certain part of the building with single and double glazing and with attractive boards and graphic displays to be used in these areas.

Erke Green Academy uses some of the existing features on site and transportation, water and energy for the purpose of teaching sustainability. However, it also has design features that can be potential educational tools within the scope of other titles (Figure 9). Information boards, towards the use of green roof and different types of paving materials providing transition of rainwater to underground, can bring a new perspective to outdoor space use. It is necessary to use educational methods to introduce the principles and systems of available sustainable features in lighting, ventilation, heating-cooling, renewable energy use and insulation issues. For example, making the circulation lines of the heat pump visible in certain areas of the building will allow the system to be perceived. Examples of previous uses of materials with recycled content and local materials may be included in the building in order to transfer these properties to visitors. Thus, people can perceive different forms of use and transformation of materials concretely. Environmental advantages provided by the structure built with 60% protection of an existing structure, the environmental effects of construction and demolition activities, and the protected parts of the existing structure can also be explained by the visible and interesting items.

Eser Green Building is a building with a wide range of features that can be used as an educational tool within the framework of sustainable design topics, but it already takes the advantage of this potential at a quite low rate (Figure 9). Systems for alternative energy sources can be observed through a variety of examples located within the Energy Theme

Park, which is reserved for public use by the company at its own discretion. In addition, landscape elements such as native plant species without irrigation need, porous paving materials will also support outdoor space use in the park area. The building with water use and conservation features such as gray water treatment, water-saving faucets and the use of rainwater in irrigation does not have the educational characteristics of working principles for these systems. These features are included on the internet page of the company. For this purpose, providing information boards and animations in the building which will provide information on working principles of the systems and follow-up of the usage data will make the systems more attractive. Taking place of an educational department includes the selection criteria and the samples of sustainable materials used in the construction will trigger a sense of curiosity for users and the visitors.

CONCLUSION

While some features of buildings designed with sustainable architectural design can be integrated to sustainability education more easily, some features can be unfortunately more difficult to integrate. The inclusion of sustainable features that will vary in the direction of the priorities of the place in the design of such buildings will lead to a more accurate and objective understanding of the concept of sustainability. For this purpose, it is necessary to plan the early stages of the design process of how and in what way the environmental characteristics of the building will be used as an educational tool. In this context, researches in the interface between physical environment and educational theories which do not yet exist in sufficient and rich variety in the literature should increase. At this point, it is important for the building design team to be interdisciplinary including various engineering disciplines and educational scientists.

In the framework of information obtained in this study, suggestions are found towards improving the informal educational building examples tasked with the sustainability education in Türkiye. Guidelines for future designs to be carried out in this context can be summarized as follows:

- National cases are open for development both in terms of the duration of training, which is limited to "hours" and the qualifications and methods of the applied trainings compared with international cases. Persistent information can be obtained in individuals by constructing sample structures or systems in order to learn by doing and the information that is theoretically learned in the framework of daily and weekly activities. It is important that the centers with sufficient area are extended to include accommodation. Furthermore, community members of all age groups, not just children and young people in school age, should be encouraged to use such buildings.
- Teaching sustainability through buildings currently takes place in museums, education centers (eco-building) and some mixed-

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use buildings in Türkiye. Just as in the international arena, it is hoped that libraries will be added to these buildings in the coming years.

- Making sustainable systems and material usage as visible and traceable as possible throughout the building can be an important learning tool. Making various systems, floor, wall, roof and insulation details transparent will ensure permanent learning on visitors.
- Outside spaces of the buildings have great potential in the context of sustainability education. Importance should be given to open space usage designing the buildings inside and outside integrated. For example, approaches such as the use of open air classes, turning of information boards and directors for structural systems into landscape items can be quite useful.
- Sustainable features of the buildings regarding indoor environmental quality wasn't seen to be reflected in education. In order to solve this problem;
    - Individuals can understand the relationship between sustainability and interior environmental quality with different activities such as discussing the effects of thermal, auditory and visual comfort conditions on both the environment and the users, experiencing the effects of different conditions on the individual. The effect of sun shading elements on the visual comfort which can be used in the appropriate directions in the buildings can be explained.
    - Introducing harmful organic compounds that affect indoor air quality, sharing daily experiences in this regard. The use of plant species that increase the amount of O2 by reducing the influence of CO2 and other harmful gases in the interiors, explaining this property to the visitors by using suitable educational materials,
    - Measuring the temperature, humidity and air quality in spaces with CO2 sensors to be placed at various points of the buildings, connection of natural and artificial ventilation system in case of necessity, presentation of this equipment through screens,
- Improvements on the water conservation can be provided by methods such as supporting groundwater with the use of high water-permeable paving materials and the use of rainwater for irrigation purposes by accumulating. These features can also be beneficial for educational purposes.
- The choice and use of sustainable materials in buildings and explaining material properties to visitors are relatively easy to achieve than other titles. Especially, transparenting materials that have different functions such as floor, wall, ceiling,

ventilation, lighting in the building and presenting to the visitors is used in many international examples as a method of evoking curiosity. The use of such methods is not observed in national samples, material presentation and use are presented to visitors via building models.

Innovative solutions in the field of architectural design will be achieved by questioning the relationship between learning methods that are used in teaching sustainability and architecture. In this context, studies integrating educational sciences with architecture will be important to continue to develop the subject in the future.

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Resume

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