Exploring the Role of Technology and Innovation in Vernacular Architecture: A case study of the Green School in Bali

Mohamed Hassan Atwa Eldek*, Ahmed Mohamed Saleh Khedr, Mervat Abdel Aziz Nasr***, Nada Magdy Mahmoud Abdallah*****

* Professor at Department of architecture, and urban planning, Faculty of Engineering, Suez Canal University, Ismailia, Egypt
** Professor at Department of Architecture and Urban Planning, Faculty of Engineering, Suez Canal University, Ismailia, Egypt
*** Professor Emeritus at Department of Architecture and Urban Planning, Faculty of Engineering, Suez Canal University, Ismailia, Egypt

DOI: 10.29322/IJSRP.14.02.2024.p14605
https://dx.doi.org/10.29322/IJSRP.14.02.2024.p14605

Paper Received Date: 14th December 2023
Paper Acceptance Date: 23rd January 2024
Paper Publication Date: 6th February 2024

Abstract- This paper examines the role of technology and innovation in vernacular architecture through a case study of the Green School in Bali. The objective is to explore how technology and innovative approaches have been integrated into the design and construction of the Green School, contributing to sustainable architectural practices and environmental conservation. The study analyzes the technological advancements implemented in the school's infrastructure and highlights their impact on achieving a balance between the built environment and nature. Furthermore, it investigates the ways in which technology and innovation enhance the learning experience and promote sustainable interaction with the surrounding environment. The findings of this study shed light on the potential of technology-driven strategies in advancing vernacular architecture and provide valuable insights for architects, educators, and policymakers seeking to promote sustainable practices in educational institutions.

Keywords: technology – innovation – vernacular architecture – sustainable practices – environmental conservation – education.

I. INTRODUCTION

Vernacular architecture, with its emphasis on locally adapted building practices, has long been recognized as a sustainable approach to construction. It integrates traditional knowledge, materials, and techniques that are well-suited to the local climate, culture, and available resources. In recent years, with the advancement of technology and the need for sustainable solutions, the role of technology and innovation in vernacular architecture has gained significant attention. This paper aims to explore the intersection of technology, innovation, and vernacular architecture through a case study of the Green School in Bali.

The Green School, located in Bali, Indonesia, is renowned for its commitment to sustainability and innovative architectural design. Founded in 2008, the school serves as an inspiring model of sustainable education with a focus on environmental stewardship and holistic learning. It is situated in a lush, green area on the edge of a tropical rainforest, providing a unique context for exploring the integration of technology and innovation in vernacular architecture.

The primary objective of this study is to investigate how technology and innovative approaches have been incorporated into the design and construction of the Green School, specifically in relation to vernacular architecture principles. By examining the various technological advancements implemented in the school's infrastructure, we seek to understand their role in achieving a harmonious balance between the built environment and nature.

Furthermore, this study aims to explore the impact of technology and innovation on the learning experience within the Green School. By analyzing the ways in which technology is integrated into the educational curriculum, outdoor activities, and field trips, we can assess how it enhances students' understanding of and interaction with the surrounding environment. Additionally, we will examine how these technological interventions contribute to the school's sustainability goals and promote sustainable practices among students and

the wider community.

By conducting an in-depth case study of the Green School in Bali, this research aims to contribute to the existing body of knowledge on the role of technology and innovation in vernacular architecture. The findings will provide valuable insights for architects, educators, and policymakers interested in promoting sustainable practices in educational institutions and beyond. Ultimately, this study seeks to inspire further exploration and implementation of technology-driven strategies in vernacular architecture, leading to more sustainable and environmentally conscious built environments.

A. Methodology

In order to achieve the objectives of this study, a mixed-methods approach will be employed. Primary data will be collected through site observations, and documentation of the technological features and innovations within the Green School. Additionally, secondary data from scholarly articles, reports, and publications on sustainable architecture, vernacular architecture, and the integration of technology in educational settings will be reviewed and analyzed.

The data obtained will be systematically analyzed to identify key themes and patterns related to the role of technology and innovation in vernacular architecture. The findings will be presented and discussed, providing a comprehensive understanding of the ways in which technology in vernacular architecture enhances sustainable practices, environmental conservation, and the learning experience within the Green School.

B. Structure of the Paper

This paper is structured as follows: Section II provides a comprehensive review of the existing literature on vernacular architecture, sustainable practices, and the integration of technology in educational settings. Section III presents the methodology employed in this study to collect and analyze data. Section IV presents the findings of the case study, highlighting the various technological advancements and their impact on sustainable architecture within the Green School. Section V discusses the implications of the findings and provides recommendations for architects. Finally, Section VI concludes the paper by summarizing the key findings and emphasizing the significance of technology and innovation in advancing vernacular architecture and sustainable practices.

II. LITERATURE REVIEW

Vernacular architecture is an important source of inspiration for contemporary architectural design solutions, as it reflects the specific needs, values, and ways of living of the cultures that produce it [1]. According to [2] Vernacular architecture refers to the traditional building practices and designs that are specific to a particular region or community, often incorporating local materials and construction techniques. While [3] stated that vernacular architecture is characterized by its close connection to the cultural values, needs, and way of life of a particular community. Also, according to [4] vernacular architecture is characterized by its use of local building materials and construction techniques, which contribute to its success and sustainability. The study of vernacular architecture combines disciplines such as architecture, anthropology, history, and geography, providing a holistic understanding of its significance [1].

Vernacular architecture refers to locally adapted building practices that respond to the environmental, cultural, and social contexts of a particular region. It emphasizes the use of local materials, traditional construction techniques, and indigenous knowledge. Previous studies have recognized vernacular architecture as an inherently sustainable approach due to its harmonious relationship with the environment [5]. Vernacular constructions have been continuously adapted to climate conditions, excessive loadings, and changes in functionality to achieve desired performance [4].

Technology and innovation can play a significant role in the development and enhancement of vernacular architecture. The role of technology and innovation in vernacular architecture extends beyond aesthetics and construction techniques, encompassing aspects such as energy efficiency, material selection, and environmental sustainability. The integration of technology and innovation in vernacular architecture has the potential to enhance sustainability, energy efficiency, and environmental performance [2]. The Green School in Bali project showcases how technology and innovation can be used to create sustainable and environmentally friendly architectural solutions within the context of vernacular architecture.

The Green School in Bali serves as a case study to explore the integration of technology and innovation in vernacular architecture. The Green School in Bali can be defined as an educational institution that integrates sustainable practices into its operations, curriculum, and culture, fostering environmental awareness among students, teachers, and the broader community. According to [6] the concept of the Green School in Bali is contested and complex. Therefore, the school's green concept, including the use of sustainable materials and

renewable energy sources, contributes to creating an environmentally conscious community [7]. The Green School in Bali exemplifies the potential of vernacular architecture in promoting sustainable practices and embracing local cultural elements [8].

In recent years, technology and innovation have played a significant role in advancing sustainable practices within the field of vernacular architecture [7]. Researchers have explored the integration of modern technologies and innovative design strategies to enhance the performance and sustainability of vernacular buildings. The Green School in Sibajang Kaja Badung, Bali, Indonesia showcases innovative architectural design using vernacular materials such as bamboo and straw roofs [8]. It exemplifies this approach by combining traditional techniques with cutting-edge technologies to achieve its sustainability goals. The Green School Bali's innovative use of technology complements its vernacular architecture, enhancing the learning experience [5].

Research has identified several key characteristics of the Green School in Bali. Firstly, it prioritizes a holistic approach, encompassing environmental, social, and economic dimensions of sustainability [9]. This includes promoting eco-friendly practices, resource conservation, and health and well-being of students and staff. Secondly, Green Schools focus on sustainable building design and operation, incorporating energy-efficient systems, renewable energy sources, and sustainable materials. Thirdly, green curriculum plays a crucial role, integrating environmental education across subjects and fostering sustainability literacy [9]. The integration of sustainable architecture and eco-friendly practices in the school's curriculum fosters an understanding and appreciation of the environment among students [7]. These characteristics collectively contribute to creating a sustainable learning environment that supports the overall goals of Vernacular School.

III. METHODOLOGY

A. Research design and approach

The research design employed in this study aimed to investigate the sustainable practices and vernacular architectural design of the Green School in Bali. It followed a qualitative research approach, which involved gathering and analyzing information from various sources to gain an in-depth understanding of the subject matter. The study utilized a case study approach to examine the Green School as a specific example of vernacular architecture and sustainable education.

B. Data collection methods

To gather relevant data, Literature Review method was employed through a comprehensive review of existing literature, including scientific journals, research publications, and relevant sources, was conducted to gain insight into the concepts of vernacular architecture, sustainable practices, and the Green School in Bali. Also, Document Analysis method using the school’s official documents and previous case studies for the Green School in Bali which served as the primary source of information for this study, was thoroughly examined and analyzed to extract relevant data on the architectural design, environmental approaches, and psychological factors of the Green School.

C. Data analysis techniques

The collected data was subjected to the following analysis techniques:

Content Analysis: The school’s documents and other relevant documents were analyzed using content analysis techniques. This involved systematically categorizing and coding the data to identify key themes, patterns, and characteristics related to the research objectives.

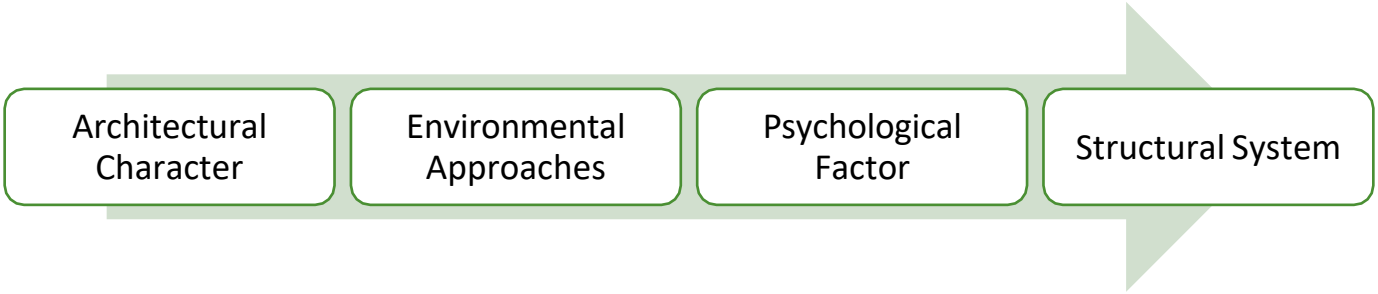
Qualitative Data Analysis: The qualitative data, including the school’s site plan observations and information from the literature review, were analyzed using qualitative analysis methods. This involved interpreting and making sense of the data to uncover meaningful insights and draw conclusions.

Comparative Analysis: A comparative analysis was performed to compare the findings from the Green School case study with existing knowledge and practices in the field of vernacular architecture and sustainable education. This allowed for a deeper understanding of the school's unique contributions and its alignment with broader sustainability goals.

IV. CASE STUDY

Green School is a private, non-profit international school founded in 2008 in Bali, Indonesia. The school is located in a lush, green area on the edge of a tropical rainforest. Green School is committed to a philosophy of environmental education, which means teaching students how to live in harmony with nature. The school follows an integrated curriculum that focuses on developing students' critical thinking, innovation, and problem-solving skills. All subjects are taught in a global context, and students are encouraged to learn outside the classroom through outdoor activities and field trips. The school also has a diverse student body from all over the world, and it is committed to teaching students to understand and respect different cultures. Green School is a leading example of sustainable education. It proves that education can be a powerful tool for creating a more sustainable future [10].

Study Axes of the School:



A. Impact of the Architectural Character of the Area on the Design and Construction of Green School:

The architectural character of the area where Green School is located had a significant impact on the design and construction of the school. The area is known for its traditional architecture, with many homes and villages made of natural materials such as wood and stone. As a result, it was important for Green School to be in harmony with its surroundings. To achieve this, bamboo was used in the construction of the school. Bamboo is a local and sustainable material that is used in many architectural applications in Indonesia. It is strong, lightweight, and can withstand the tropical climate [11].

Figure 1 *Perspective View of Interior of Green School Bali, Showing the Use of Bamboo*
Source: https://shorturl.at/coAM7

A.1. Design Concept:

To inspire students to become more engaged with their surroundings and their community, to motivate communities to live in a more natural and environmentally friendly way, and to demonstrate how to build sustainably using local, primitive materials such as bamboo through experimental and innovative methods to prove the possibility of self-construction, thus stimulating students' interest in learning [12].

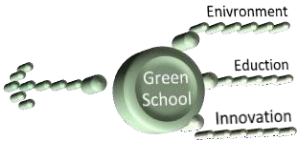


Figure 2 *Explains the design idea of the school.*
Source: *Researcher*

A.2. SITE PLAN {FIRE & EVACUATION ROUTES}:

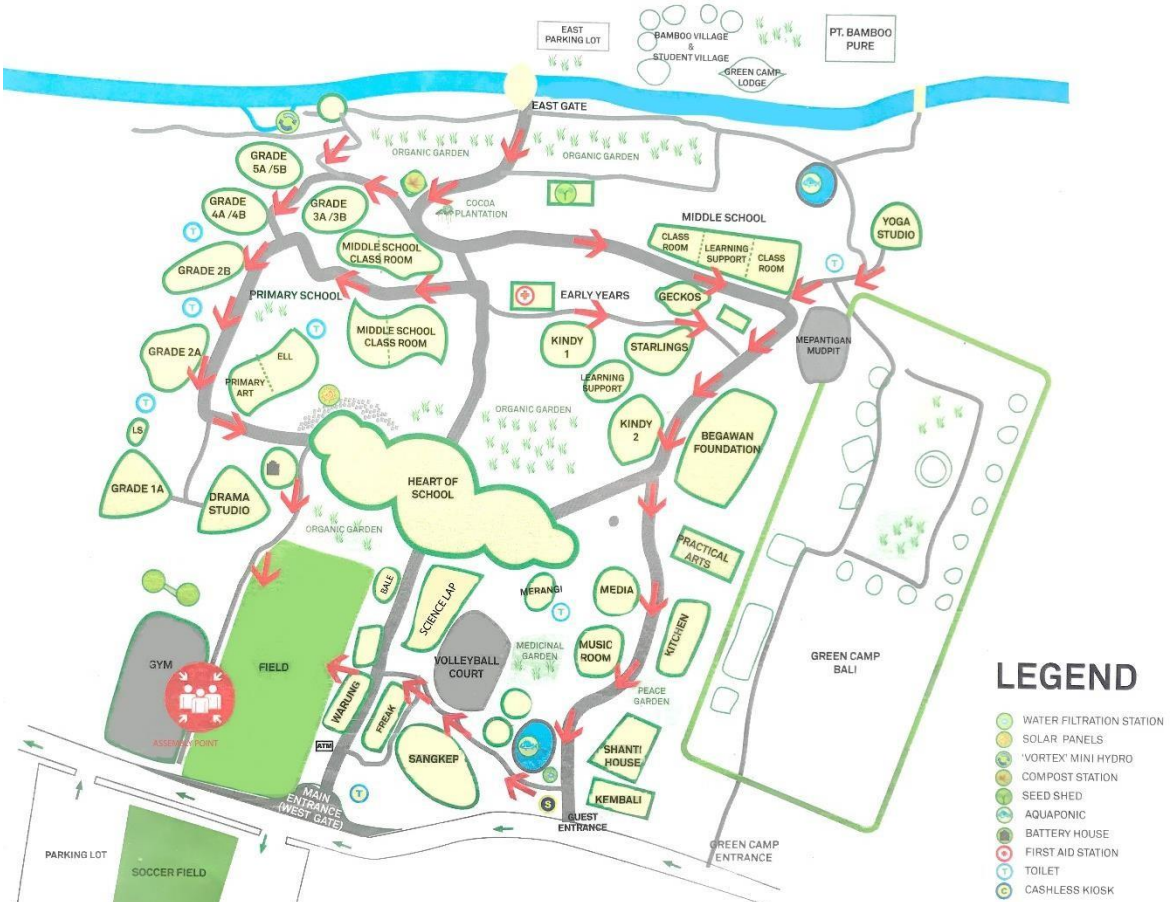


Figure 3 *SITE PLAN TO THE GREEN SCHOOL IN BALI*
Source: *Researcher*

B. Environmental Treatments:

B.1 Use of Bamboo:

Bamboo is a fast-growing plant that can be harvested in a short period of time. It is a strong and durable material that is also a good insulator. The hollow structure of bamboo helps to keep buildings cool in hot climates [12].

Figure 4 *SECTION IN BAMBOO*
Source: *https://shorturl.at/axLQW*

B.2 Sloping Roofs:

The region is characterized by heavy rainfall and scorching sun throughout the year. To overcome these climatic conditions, the designer built sloping roofs and openings in the roofs to maintain natural light in the site. The roofs were made of local materials, such as fabric, straw, and rubber supported by bamboo. However, the rubber was damaged by the sun, so it was replaced with recyclable plastic materials [13].

Figure 5 *The use of roof openings from local materials*
Source: *https://shorturl.at/axLQW*

B.3 Use of Natural Lighting:

Slit and circular openings were used in the roofs to allow natural light into the spaces. The openings were treated with recyclable plastic materials to allow light in, but not direct sunlight. Calculations were made to adjust the angles of sunlight with the inclinations of the roof openings to allow light to reach deep into the spaces. The external walls were left open during the day to allow for efficient daylighting for studying. At night, additional low-energy lighting was integrated to meet the lighting needs. This lighting was powered by renewable energy sources, such as solar panels or water turbines [11].

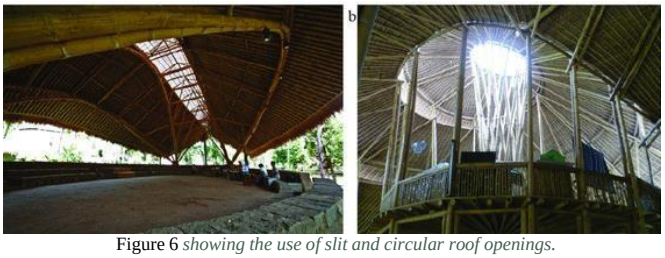


Figure 6 *showing the use of slit and circular roof openings.*
Source: *https://shorturl.at/hvFSX*

B.4 Electricity Production:

Hydropower	Solar Power:	Organic Energy
The second hydro turbine in the world was built, pumping 2.5 meters of water over a river. The turbines produce 8,000 watts of electricity throughout the morning and evening **[13]**.	The school is in a region with intense sunlight throughout the year, making solar power an important and practical component of the Green School's renewable energy strategy. In 2011, Akuo Energy donated a photovoltaic and solar energy management system. The photovoltaic system consists of 118 solar panels, a 72-kilowatt-hour battery bank, and inverters [14].	Bamboo sawdust, rice straw, and other organic materials are burned to produce energy to heat hot water for cooking [13].
		
Figure 7 ***showing the hydro turbine.*** **Source:https://www.ted.com/talks/john_hardy_my_green_school_dream**	Figure 8 *shows the solar panels.* Source:https://www.zeromasswater.com/na/library/the-green-school	Figure 9 *shows the use of a wood-fired oven to cook.* Source:https://www.ted.com/talks/john_hardy_my_green_school_dream

B.5 Use of natural water bodies:

The school was built next to a river in Kaja Sibang to help cool the air. The river is used to irrigate the gardens and crops. Drinking water is sourced from a well that is 60 meters deep. Although well water is safe to drink, a Reverse Osmosis (RO) filtration and purification system was installed to ensure the purity and safety of drinking water for the community [14].

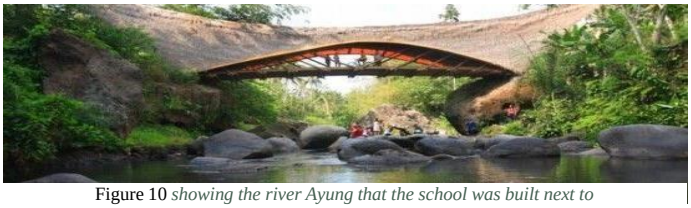


Figure 10 *showing the river Ayung that the school was built next to*
Source: https://www.pinterest.com/pin/384424518163226939

B.6 Pavement and pathways:

The pavement and pathways are free of petrochemicals. The pavement is made of gravel, but it is covered with plants and grass. The gravel is only visible during the rain. The pathways are made of hand-laid volcanic rock [13].

Figure 11 *Showing the pavement and pathways.*
Source:https://www.ted.com/talks/john_hardy_my_green_school_dream

B.7 Natural ventilation:

The classrooms are designed without walls to allow the breeze from the Ayung River to pass through the classrooms. When the natural breeze is not sufficient to cool the classrooms, students move to the bubble classrooms, which are made of rubber from natural rubber trees and cotton [13].

Figure 12 *showing Bubble classrooms when they open and close.*
Source:https://www.flickriver.com/photos/gregersreimann/sets/72157623535475431

B.8 Soundproofing:

The bubble classrooms are used for soundproofing when there is noise. In addition, the straw used on the ceilings is a good sound insulator [13].

Figure 13 *bubble classrooms designed to be soundproof, and the ceiling of the classroom is made of straw.*
Source: *https://www.flickriver.com/photos/gregersreimann/sets/72157623535475431*

B.9 Waste Management:

Waste at school is part of a closed-loop system, understanding how to recycle it back through the environment. They strive to create a closed-loop system from the food forest and gardens to the kitchen, to the compost pile and greywater management system, back to our lunch trays, and finally to the composting toilet for another cycle.

Figure 14 *Showing the Collecting of waste for recycling.*
Source: http://soulcuisine.co.nz/bali-green-school

<u>There are four main streams of solid waste that we need to manage at the green school:</u>

- Food waste from the kitchen is either fed to the pigs or sent to our composting facility for recycling. The biomass waste produced by the gardens and landscapes throughout their life cycle is used as an input material in the biodigester station.
- Human waste or sewage is recycled through our composting toilet system, which is then recycled back into the soil, becoming fertile ground for growing bamboo and bananas.
- Industrial and office waste is delivered to Kembali, a social enterprise that collects recyclable materials from the green school and the surrounding community for pickup by a local partner for recycling.
- This aligns with the principles of the circular economy where there is no such thing as waste, moving away from the destructive practices of the "Take, Make, Waste" system of industrial production and consumption prevalent in contemporary society.

Figure 16 *Composting toilet and sawdust.*
Source:https://www.flickriver.com/photos/gregersreimann/4449577398

Figure 15 *Children's farming of recycled compost*
Source:https://lifeandsoulmagazine.com/2018/02/10/green-school-bali-jungle-based-school-teaching-pupils-to-be-green-leader

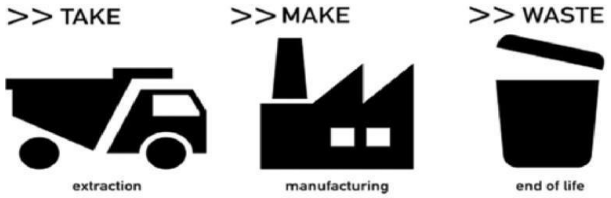


Figure 17 *System of take, make & waste.*
Source:https://www.researchgate.net/figure/Take-make-and-waste-the-linear-economy-Image-credit-Jennifer-Whitty-2017_fig1_333603260

B.10 School Furniture:

Local bamboo has been used in the interior furnishings of the school to give a distinctive architectural character that suits the surrounding environment of the school, which is an integral part of nature. Traditional teaching methods have also been employed, with the black bamboo wood used to create the blackboard.

Figure 18 Showing the furniture of the school made from Local bamboo.
Source:https://www.flickriver.com/photos/gregersreimann/4449577398

C. Psychological Factor:

The design and construction materials of the school have an impact on the psychological well-being of students and teachers. When school becomes integrated with nature, it enhances a sense of psychological comfort, connection, and belonging. During the construction of the school, children, parents, and school users were involved in the building process, like building their own homes. Additionally, the use of local building materials within the spaces and their arrangement gives a sense of containment and familiarity. The interior spaces differ from the traditional setup, as both students and teachers sit on bamboo mats, fostering a more inclusive and conducive dialogue for better knowledge sharing and exchange of opinions. This takes place within an open space, or one made of transparent materials, making students more attentive. The availability of various social activities helps students feel more psychologically at ease and allows their talents to flourish.

D. Structural System:

The construction was carried out using low-cost and easily transportable local building materials. Bali, Indonesia, is known for its dense forests and abundant trees, which are used in house construction. The architectural style of Bali revolves around building with wood, and the architect aimed to maintain that character while making it unique. Bamboo, known for its ease of cutting and shaping, was used. Vernacular architecture using bamboo materials is a prominent feature of the Green School Bali's infrastructure [5]. The architect assembled and shaped a collection of bamboo poles to form the structural framework. The standard of bamboo construction aims to provide improvement in hygiene, withstand natural disasters, meet owner/occupier needs, and serve as an educational tool [15].

The integration of bamboo in the construction demonstrates the role of technology and innovation in creating sustainable and environmentally friendly educational spaces [8]. Common bamboo joints include basic end joints, joints with 'ears' for compression, tilted cuts for truss systems, and joints with wooden pins and dowels. Different types of bamboo joints include longitudinal joints for lengthening bamboo stems, cross-section joints with pegs and lashings, and joints found in roof structures [15]. Bamboo joints in roof structures involve rope/lashing systems, dowels, and bamboo culms trimmed and engulfing each other. The use of bamboo and other environmentally friendly materials in the school's construction showcases the potential of vernacular architecture in sustainable design [7].

V. IMPLICATIONS AND RECOMMENDATIONS

A. Implications of the Findings:

The findings of the study on the role of technology and innovation in vernacular architecture, focusing on the case study of the Green School in Bali, have significant implications for architects and engineers in other departments. The following implications emerge from the research:

1. Integration of Modern Technologies: The Green School in Bali demonstrates how the integration of modern technologies can enhance the performance and sustainability of vernacular buildings. Architects and engineers should explore innovative design strategies and incorporate cutting-edge technologies to achieve sustainability goals while preserving the cultural and environmental aspects of the built environment.
2. Sustainable Building Design and Operation: The Green School's emphasis on sustainable building design and operation is crucial. Architects and engineers should prioritize energy-efficient systems, renewable energy sources, and sustainable materials in their projects. By adopting such practices, they can contribute to creating environmentally conscious communities and reducing the ecological footprint of buildings.
3. Holistic Approach to Sustainability: The Green School's holistic approach, encompassing environmental, social, and economic dimensions of sustainability, sets a valuable example. Architects and engineers should consider the broader impact of their designs on the well-being of students, staff, and the surrounding community. This entails promoting eco-friendly practices, resource conservation, and the health and well-being of building occupants.
4. Integration of Sustainability in Curriculum: The Green School's green curriculum plays a significant role in fostering sustainability literacy among students. Architects and engineers should collaborate with educational institutions to integrate

environmental education across subjects. By doing so, they can contribute to developing a future generation that values and understands the importance of sustainable practices in architecture and engineering.

B. Recommendations for Architects and Engineers:

Based on the findings of the study, the following recommendations are offered to architects and engineers from other departments:

1. Embrace Vernacular Architecture: Architects and engineers should explore the principles and techniques of vernacular architecture and incorporate them into their designs. By using locally available materials, traditional construction methods, and cultural elements, they can create sustainable and contextually relevant buildings that reflect the local identity.
2. Foster Collaboration: Architects and engineers should collaborate with professionals from diverse fields, including environmental scientists, educators, and community stakeholders. This multidisciplinary approach can lead to innovative solutions and a more comprehensive understanding of sustainability in the built environment.
3. Emphasize Renewable Energy: Architects and engineers should prioritize the integration of renewable energy sources, such as solar panels and wind turbines, in building design. By incorporating these technologies, they can reduce reliance on fossil fuels and contribute to a more sustainable energy future.
4. Continuous Learning and Research: Architects and engineers should stay updated with the latest advancements in sustainable technologies and design practices. Continuous learning and research will enable them to incorporate innovative solutions and adapt to evolving sustainability standards.
5. Disseminate Knowledge and Best Practices: Architects and engineers should actively share their knowledge and best practices related to sustainable architecture and engineering. This can be done through publications, conferences, workshops, and collaborations with educational institutions. By disseminating knowledge, they can inspire and influence others to adopt sustainable approaches.

VI. CONCLUSION

In conclusion, this study has shed light on the role of technology and innovation in advancing vernacular architecture and promoting sustainable practices. Through the case study of the Green School in Bali, it has become evident that the integration of modern technologies and innovative design strategies can greatly enhance the performance, sustainability, and overall learning experience withinthe field of vernacular architecture.

The key findings of this research highlight several important aspects. Firstly, the Green School exemplifies the potential of vernacular architecture in promoting sustainable practices and embracing local cultural elements. By combining traditional techniques with cutting-edge technologies, the school has successfully achieved its sustainability goals while maintaining a strong connection to the environment and the surrounding community.

Secondly, the study emphasizes the significance of a holistic approach to sustainability. The Green School prioritizes the environmental, social, and economic dimensions of sustainability, promoting eco-friendly practices, resource conservation, and the well-being of students and staff. This comprehensive approach creates a sustainable learning environment that supports the overall goals of vernacular education.

Moreover, the integration of sustainable architecture and eco-friendly practices in the school's curriculum fosters an understanding and appreciation of the environment among students. By incorporating environmental education across subjects, the Green School cultivates sustainability literacy and prepares future generations to be conscious stewards of the built environment.

The significance of technology and innovation in advancing vernacular architecture and sustainable practices cannot be overstated. By embracing modern technologies, architects and engineers can enhance the performance and sustainability of vernacular buildings while preserving cultural and environmental aspects. The integration of renewable energy sources, energy-efficient systems, and sustainable materials in building design and operation is crucial for reducing the ecological footprint and creating environmentally conscious communities.

In conclusion, this research underscores the importance of technology and innovation in the realm of vernacular architecture. Architects and engineers from various departments are encouraged to embrace the principles and techniques of vernacular architecture, foster collaboration with different disciplines, emphasize renewable energy, engage in continuous learning and research, and actively disseminate knowledge and best practices. By doing so, they can contribute to the advancement of sustainable practices, the preservation of cultural heritage, and the creation of a more environmentally conscious built environment.

Overall, the findings of this study provide valuable insights into the significant role that technology and innovation play in advancing vernacular architecture and promoting sustainable practices. It is hoped that this research will inspire further exploration and implementation of these principles in architectural and engineering endeavors worldwide, leading to a more sustainable and harmonious built environment for future generations.

REFERENCES

[1] L. Bianco, "Rural and urban vernacular architecture of the Mediterranean - a source for contemporary, contextual, architectural design solutions," in *The 5th Electronic International Interdisciplinary Conference*, Malta, 2016.

[2] M. Philokyprou and A. Michael, "Evaluation of the Envrionmental Features of Vernacular Architecture A Case Study in Cyprus," *International Journal of Heritage in the Digital Era*, vol. 1, no. 1, pp. 349-354, 2012.

[3] B. M. A. Khaznadar and M. A. B. Khayat, "Formal characteristics of vernacular architecture in Erbil city and other Iraqi cities," *Iraqi Journal of Architecture and Planning*, vol. 9, no. 19, pp. 213-233, 2010.

[4] H. Azizi-Bondarabadi and N. Haji Sadeghi, "Local seismic culture in Iranian vernacular architecture: evidence from Yazd earthen architecture," *Built Heritage*, vol. 6, no. 5, 2022.

[5] N. P. T. Widanti, "Khazanah Ekoleksikon 'Green' di Green School Bali," *Journal of Bali Studies*, vol. 12, no. 02, pp. 378-402, October 2022.

[6] A. Iwan and R. Nirmala , "The green school concept: Perspectives of stakeholders from award-winning green preschools in Bali, Berkeley, and Hong Kong.," *The Journal of Sustainability Education*, vol. 16, December 2017.

[7] N. N. Alimin, E. G. Pertiwi and L. Purwaningrum, "Establishing sustainable habits of students in Green School Bali through green interior design," in *IOP Conference Series: Earth and Environmental Science*, 2021.

[8] A. Landwehr and P. Bambú, "Green School in Sibajang Kaja Badung, Bali, Indonesia," in *Building with Bamboo: Design and Technology of a Sustainable Architecture*, 2nd ed., Berlin, Boston, Birkhäuser , 2016, pp. 105-107.

[9] A. Iwan, N. Rao and K. K. Poon, "Characteristics of green schools: Observations of award-winning green preschools in Bali, Berkeley and Hong Kong," *Journal of Education for Sustainable Development*, vol. 12, no. 2, pp. 140-159, 2018.

[10] John and K. Hardy, The Green School: A Sustainability Odyssey, 2012.

[11] B. Shim, "Green School," 2010.

[12] Aga Khan Development Network, "THE GREEN SCHOOL," Aga Khan Foundation, [Online]. Available: https://www.akdn.org/architecture/project/green-school. [Accessed 12 Septemper 2023].

[13] J. Hardy, "My green school dream," TED Conferences, July 2010. [Online]. Available: https://www.ted.com/talks/john_hardy_my_green_school_dream. [Accessed 20 August 2023].

[14] Yayasan Kul Kul, "Learning Environment in Bali, Indonesia," Green School Bali, 2021. [Online]. Available: https://www.greenschool.org/bali/environment/. [Accessed 26 August 2023].

[15] D. P. M. Gusti and H. Xiaofeng, "Bamboo Joints Review on the Millennium Bridge in Green School Bali," *Arts and Design Studies*, vol. 91, pp. 29-36, 31 March 2021.

[16] O. E. Hapsari, "Analisis Penerapan Green Building Pada Bangunan Pendidikan (Studi Kasus: Green School Bali)," *AL-ARD: JURNAL TEKNIK LINGKUNGAN*, vol. 3, no. 2, pp. 54-61, March 2018.

[17] Y. O. Butsykina, "VERNACULAR CULTURE, CITY, ARCHITECTURE: ANALYSIS AND CORRELATION OF CONCEPTS," *UKRAINIAN CULTURAL STUDIES*, pp. 56-59, 2021.

[18] . P. Robinson, "Urban Vernacular Housing in Newtownards, County," *Folk Life*, vol. 17, no. 1, pp. 20-38, 1979.

[19] C. Roels, "The Contemporary Debate on the Definition of Vernacular Architecture: an overview.," in *The international Congress of the European Architectural History Network*, Brussels, 2012.

[20] I. FARDOUS and A. BENNADJI, "Impact of Technology and Innovation on Adaptation of Architectonic Tradition for a Sustainable Future in the Middle East," *Journal of civil engineering and architecture*, vol. 13, no. 4, pp. 273-281, 2019.

AUTHORS

First Author – Mohamed Hassan Atwa Eldek, Professor at Department of architecture, design, and urban planning, Suez Canal University, Ismailia, Egypt**.**
Second Author – Ahmed Mohamed Saleh Khedr, Professor at Department of architecture, design, and urban planning, Suez Canal University, Ismailia, Egypt.
Third Author – Mervat Abdel Aziz Nasr, Professor Emeritus at Department of architecture, design, and urban planning, Suez Canal University, Ismailia, Egypt.
Fourth Author – Nada Magdy Mahmoud, Senior Architect, NadaMagdy06@gmail.com.
Correspondence Author – Nada Magdy Mahmoud Abd-Allah, NadaMagdy06@gmail.com, (+2) 01220546404.