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Challenges of Implementing Biophilic Design in Repurposed Schools in Karachi, Pakistan

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Abstract

Rapid and largely unplanned urban growth in Karachi has pushed many private schools into converted houses, apartments and other makeshift premises. These buildings were never meant to be classrooms, and they seldom have the daylight, ventilation, greenery or open space that a good learning environment needs. This study asks why biophilic design, the practice of bringing nature into built space, is so rarely found in such schools, and what teachers, students and design professionals think about it. A mixed-method design was used. A literature review on biophilic patterns and informal educational infrastructure was combined with field observation in repurposed schools and a structured questionnaire of closed-ended items, with field notes taken during interviews to record context. Responses were summarised as percentages and bar charts, and the barriers were organised in an Ishikawa (cause-and-effect) diagram. Respondents were strongly in favour of natural features. About 91% believed that sunlight, plants and outdoor views improve well-being, and 53 per cent preferred a nature-rich space over a plain traditional or a high-tech classroom. Nearly two-thirds reported feeling more stressed when nature was missing. Yet only about a quarter of classrooms had good natural light or greenery. Respondents blamed limited awareness (53%) more often than limited budgets (38%) or the makeshift nature of the building (9%). Four groups of barriers emerged: social and cultural, environmental and climatic, technical and design-related, and policy and regulatory. The paper concludes that the gap is as much one of knowledge and policy as of money, and it proposes modular, low-cost interventions built around visual connection with nature, biomorphic forms and patterns, dynamic and diffuse light, and complexity and order.

Key words: repurposed, infrastructure, environment, framework, biophilic Design

Introduction

Karachi's continuous population growth has intensified the demands for its educational infrastructure, revealing a widening gap between the city's expanding student population and the

capacity of its schools. The pressure is reflected in overcrowded classrooms, uneven distribution of educational facilities, and persistent shortages of qualified teachers and essential resources. Beyond a question of access, this challenge concerns the city's ability to provide equitable, high-quality education amid rapid urbanization. Addressing it requires long-term planning that aligns population growth with investment in school facilities, teacher development, and comprehensive educational provision.

As Karachi's population expanded, the city's need for schools grew faster than public provision could accommodate. In response, the private sector stepped in, opening schools across neighborhoods and helping to widen access to education (Hussain 2018). Many began in converted homes and other residential buildings, which made schooling more locally available but also indistinct the boundary between domestic space and educational infrastructure. This development reflects the resourcefulness of communities and private providers, while also highlighting a deeper challenge: ensuring that the rapid expansion of schools is matched by safe, purpose-designed facilities and consistent educational quality.

The repurposing of residential buildings into schools reflects both the urgency of educational demand and the inventiveness of communities responding to it. Yet the conversion of a home into a place of learning is not simply a change of use: it reshapes the conditions in which students concentrate, interact, and develop. Architecture can foster learning by offering spaces that are legible, comfortable, and responsive to different forms of teaching. Residential buildings, however, are rarely designed for the rhythms and needs of a school; constrained rooms, narrow circulation, limited daylight, poor ventilation, and a lack of outdoor space may contribute to crowding, fatigue, and distraction. Where purpose-built facilities are not possible, architects can still improve the quality of these environments through sensitive adaptation.

Biophilic design offers one such approach, reconnecting students with nature through daylight, planting, natural materials, views of greenery, and access to fresh air or small outdoor spaces. These interventions cannot erase the structural limits of a converted home, but they can make it more restorative and engaging—recognizing that the quality of the learning environment is not incidental to education, but part of its foundation.

In Karachi, the design of educational buildings is shaped by a trade-off between schools' responsibility to support students' learning and wellbeing and the financial pressures involved in

running an educational institution. Schools are not simply buildings in which lessons take place; they are environments where students spend much of their day, and where light, air, greenery, and opportunities for movement can influence comfort, concentration, and a sense of belonging. Yet these qualities may be difficult to prioritize when decisions are driven by enrolment targets, tuition revenue, operating costs, and the desire to accommodate more students within a limited site.

This pressure can lead schools to maximize classroom numbers and floor area while giving less attention to courtyards, shaded outdoor spaces, natural ventilation, and other features that connect students with nature. In this context, financial gain is not limited to the construction or sale of a building: it may also be tied to the school's capacity to enroll more students and generate income through education. The challenge is to ensure that this pursuit does not come at the expense of the learning environment. A well-designed school should be understood not merely as a means of delivering education efficiently, but as an active part of the educational experience—one that supports students' health, engagement, and development. Integrating biophilic principles into school design can therefore be seen not as an unnecessary expense, but as an investment in the quality of education and in the everyday lives of the students and teachers who use the building.

Research Question

1. What are the physical, social, economic and institutional challenges in implementing biophilic design in makeshift schools.?
2. How to environmental and contextual factors affect biophilic design adoption?
3. What is the perception of stake holders regarding biophilic design?
4. What strategies can facilitate the integration of biophilic principles in these settings?

Review of Literature

Research on how experiences of nature impact people looks at both psychological and physiological responses. It involves many fields of science, including environmental psychology, post-occupancy evaluation and neuroscience. Measurements can include heart rate, blood pressure, stress hormones, recovery time, fMRI imaging, eye tracking, cognitive performance and emotional responses. Even observing an image with natural content or viewing out briefly in in is considered a soft fascination experience., and is part of Attention Restoration Theory (ART).

Upon meticulous examination of the 24 studies included in this systematic review and synthesis, the following natural elements were recognized as influencing factors within the category of nature: natural light, natural materials, natural sound, water features, natural air, access to natural environments and views of nature (Fengyu Xia, 2023). A review of photographs published on Karachi schools' websites and Facebook pages suggests that biophilic design elements are either absent or only occasionally visible in many school buildings. This is particularly noticeable in schools operating from repurposed buildings, such as converted houses or commercial properties. In these images, learning spaces often appear to be organized around classrooms, corridors, and paved or enclosed areas.

Natural features—such as substantial planting, courtyards, daylight-oriented layouts, views of greenery, natural materials, or indoor plants—are not prominent. Where vegetation is visible, it may be limited to a few pots or small patches rather than forming an integrated part of the building or students' daily experience. Photographs may also emphasize interiors, events, and facilities, so features not shown cannot necessarily be assumed to be absent.

Repurposed school buildings may face particular constraints. Their original layouts were not designed around educational needs or connections to nature, and limited outdoor space, dense urban surroundings, and the cost of alterations can make it difficult to add gardens, shaded play areas, or well-lit communal spaces. As a result, adaptations may prioritize fitting classrooms and essential facilities into the existing structure, with biophilic considerations receiving less attention.Overall, the images provide an initial indication that biophilic design is not yet a consistent feature of the schools represented. However, this should be treated as a visual observation rather than a definitive assessment of all Karachi schools: online photographs may be selective, outdated, or incomplete.

A stronger study would verify the findings through site visits, building plans, and interviews, and assess elements such as daylight, ventilation, views of nature, planting, outdoor access, and use of natural materials. There are 15 different experiences of nature (with supporting scientific evidence of positive health impacts) that can be translated into experiences of the built environment. These experiences can be characterized into a pattern language for biophilic design. These patterns fall into three broad categories: Nature in Space, Natural Analogues, and Nature of Space.

Research by Dr. Mary Ann and Jim Determan examines how biophilic design features in educational environments may shape students' cognitive engagement and academic learning. Rather than centering on physiological measures—such as blood pressure, cortisol levels, or heart rate, which are often used to assess stress and other bodily responses—their work gives greater attention to the learning process itself. This includes students' ability to concentrate, process information, remain cognitively engaged, and participate in academic tasks.

This distinction is important: the study's emphasis is not primarily on whether nature-oriented spaces produce measurable changes in students' physical or stress-related responses, but on how these environments may support learning and classroom engagement. By foregrounding cognitive and educational outcomes, the research positions biophilic design as a potential contributor to more supportive learning environments and highlights the value of considering nature-integrated features in the design of schools.



Figure 4: Flow chart identify connection between population growth and built infrastructure

The belief that contradicts with nature restores people is far older than the modern research that supports it. Frederick Law Olmsted argued in the nineteenth century that views of natural scenery rest the mind and body in a way that built surroundings do not (Olmsted, 1865). Kaplan and Kaplan (1989) and Kaplan (1995) later gave this idea a psychological footing in Attention Restoration Theory. They proposed that everyday tasks demand effortful, directed attention, which tires with use, whereas natural settings invite what they called soft fascination: attention that is held gently without strain. During that pause the capacity for directed attention recovers. For a student who has spent a morning concentrating on arithmetic and language, a window onto a tree or a patch of sky is therefore more than decoration.

Physiological work points the same way. Ulrich (1984) found that hospital patients whose rooms

overlooked trees recovered faster and needed fewer pain medications than patients facing a brick wall. Later experiments on heart rate, blood pressure and stress hormones have repeatedly shown that natural stimuli calm the body and improve mood, a body of evidence that Browning, Ryan and Clancy (2014) drew on when describing the benefits of biophilic patterns for stress reduction, cognitive performance and emotional well-being.

Translating these findings into design guidance has been the work of Kellert, Heerwagen and Mador (2008) and Kellert and Calabrese (2015), and of Browning and colleagues. In their widely cited framework, Browning, Ryan and Clancy (2014) describe fourteen patterns, later extended to fifteen, that convert experiences of nature into qualities of the built environment. The patterns fall into three groups.

Nature in the Space covers direct experiences of nature: visual and non-visual connections, non-rhythmic sensory stimuli such as moving leaves, thermal and airflow variability, the presence of water, dynamic and diffuse light, and connection with natural systems. Natural Analogues covers indirect experiences, including biomorphic forms and patterns, a material connection with nature, and complexity and order such as fractal geometry. Nature of the Space covers the spatial character of a room: prospect, refuge, mystery, risk and peril, and awe.

Different patterns support different outcomes. Some mainly reduce stress, others improve cognitive performance, and others raise mood and preference, while several do more than one at once (Browning & Ryan, 2020). This matters for schools. A designer working with a small budget does not need to apply every pattern; the recommended approach is to decide which outcomes matter most for the users and then choose the patterns that serve them. The presentation on which this paper builds reflects this view, where the principal elements highlighted are plants, patterns, colours, natural light, shadows and natural forms.

Biophilic design in educational settings

Several studies have tested the framework in learning environments. Heschong's large study of daylight in school districts in the United States associated well-lit classrooms with faster progress in mathematics and reading. Barrett and colleagues (2015), studying 153 classrooms in the United Kingdom, found that elements such as light, air quality and flexibility, which together describe how naturally a room supports its occupants, accounted for a meaningful proportion of the variation in pupils' academic progress.

Determan and colleagues (2019) reviewed the evidence on biophilic learning spaces for the

American Institute of Architects and reported links between exposure to nature in classrooms and improved attention, engagement and student success. Browning and Determan (2024) extended this line of work by examining the outcomes of biophilic design for schools and arguing that benefits reach across health, behaviour and learning.

Work in higher education points in a similar direction. DeLauer and colleagues (2022) examined natural environments and biophilic design on a residential college campus and described how such spaces functioned as supportive and nurturing places for students. Elmashharawi (2019) argued that biophilic design can bring educational spaces to life and make them more stimulating for learners and teachers. Beyond individual outcomes, authors have also noted that daily contact with natural features can encourage pro-environmental attitudes in students, a point that fits well with wider goals of education for sustainability.

Compared with the biophilic literature, research on improvised schools is thin and mostly descriptive. In many fast-growing cities of the Global South, schools in converted dwellings are a response to shortages of land, capital and public provision. They are common where space is tight, where resources are limited, and where demand for schooling suddenly exceeds supply. The conversion may be modest, adding desks, boards and basic safety measures to an existing house, or it may involve removing partitions and combining rooms into classrooms and offices. For some schools the arrangement is temporary, but for many it becomes a semi-permanent or long-term solution.

Studies of such buildings usually concentrate on safety, overcrowding, sanitation and fire risk, which are serious concerns, and they rarely ask what kind of experience the building offers to the people inside it. The few papers that link informal school buildings to sustainability tend to treat nature-based features as a luxury. The present research challenges that assumption by asking how stakeholders themselves see nature in their schools and what keeps it out.

Research gap

Three gaps follow from this review. First, evidence on biophilic design in schools comes largely from purpose-built buildings in high-income countries. Second, little is known about how teachers, students and designers in South Asian cities view these ideas. Third, the literature seldom organises the barriers to adoption in a way that helps decision makers choose where to act first. This study contributes to all three by examining repurposed schools in Karachi, collecting stakeholder perceptions, and mapping the barriers in a structured cause-and-effect

model.

Methodology

The study follows a mixed-method design. Quantitative data were gathered through a structured questionnaire, while qualitative data came from field observation and from notes taken during informal interviews. Combining the two was deliberate. Percentages show how widely a view is held, but they say little about why a classroom without windows persists. Field notes record the surrounding details, such as the layout of a converted bedroom, the state of a rooftop, or an owner's offhand remark about the landlord, that help interpret the numbers. The literature review on biophilic principles and informal educational infrastructure supplied the conceptual framework for both instruments.

Data were collected with three tools: a literature review, an online survey and field observation. The questionnaire contained closed-ended items, each with three answer options, so that respondents could complete it quickly. The first two items asked whether the respondent's school had natural features such as plants, good sunlight or outdoor areas, and whether those features were present in most classrooms. Six further items covered beliefs about whether natural features improve well-being, whether their absence affects learning or teaching, which kind of environment people find most conducive to learning, whether mood changes when nature is missing, which classroom feature people value most, and what the main reason is for limited natural integration in their school.

Research Findings

Observation confirmed that the schools in the study have developed as a response to infrastructure strain. The chain of cause that emerged runs from rapid urban growth to a shortage of school buildings, then to improvised conversion of residential space, and finally to a set of conditions in which nature is hard to include. These conditions include limited space and resources, difficulty of construction and maintenance, a shortage of skilled labour, cost pressure and urgency, and little awareness of the benefits of natural elements. At the same time, the observations suggested a potential for resilience: because these buildings are already flexible and adaptable, they could accommodate modest biophilic additions if the challenges were addressed in a way suited to local conditions.

Presence of natural features in schools

The first two survey items describe the baseline. As Table 1 shows, 65.5 per cent of respondents

said their school had several natural features such as gardens, good sunlight or outdoor spaces, 27.6 per cent said natural features existed but were limited, and 6.9 per cent said their school had none at all. When the question moved from the school as a whole to the classroom, the picture was less favourable. Only 24.1 per cent reported that most classrooms had good natural light or greenery, 34.5 per cent said some classrooms did, and 41.4 per cent said most classrooms lacked natural features.

Table 1.

Availability of natural features in schools and classrooms

Survey item	Option 1	Option 2	Option 3
Q1. Natural features in the school (none / limited / several)	6.9%	27.6%	65.5%
Q2. Natural features in classrooms (most lack / some have / most have)	41.4%	34.5%	24.1%

The difference between the two items is worth noting. A school may have a rooftop garden or a courtyard tree, and respondents were willing to count that, but the spaces where children spend most of their day often remain closed off from daylight and green views. Field observation supported this. In several converted houses, interior rooms depended on artificial lighting, windows opened onto narrow lanes or walls, and the available outdoor space was used for assembly, play or parking rather than planting.

Perceived benefits of natural features

Respondents held strongly positive beliefs about nature. Table 2 summarises the next four items. On the first, 91.4 per cent believed that natural features such as sunlight, plants and outdoor views significantly help students and teachers feel happier and less stressed, 8.6 per cent thought the effect sometimes occurs but is small, and nobody said they noticed no difference. Asked whether the absence of natural features affects the learning or teaching experience, a smaller majority of 53.4 per cent said it makes learning and teaching less effective or less enjoyable, 41.4 per cent said the effect is slight, and 5.2 per cent said learning continues as usual.

The mood item produced the sharpest results. Only 6.9 per cent said they notice no change in mood when natural features are limited, 63.8 per cent said they feel a bit more stressed or less happy, and 29.3 per cent said they feel much more stressed or unhappy. In other words, more than nine in ten respondents reported some emotional effect.

When asked to choose the environment most conducive to learning or teaching, 53.4 per cent chose a space filled with plants, natural light and outdoor views. A high-tech classroom with screens and modern lighting was chosen by 32.8 per cent, and a traditional classroom with basic furniture and few natural features by 13.8 per cent.

Table 2.

Perceived benefits of natural features

Survey item	Most positive response	Middle response	Least positive response
Q3. Natural features improve well-being	91.4%	8.6%	0%
Q4. Absence of nature affects learning or teaching	53.4%	41.4%	5.2%
Q5. Most conducive environment (nature-rich / high-tech / traditional)	53.4%	32.8%	13.8%
Q6. Mood when nature is absent (more stressed / a bit stressed / no change)	29.3%	63.8%	6.9%

Priorities in the classroom

When respondents were asked which single feature they would prioritise to improve learning or teaching, 48.3 per cent chose large windows with natural sunlight and views of nature. Advanced technology such as interactive screens and projectors was chosen by 25.9 per cent, and the same share, 25.9 per cent, chose ergonomic furniture and natural materials such as wood and stone in the décor. Daylight and views were therefore the most valued single feature, ahead of technology. This is a notable result in a context where schools often compete for parents by advertising digital equipment, and it suggests that demand for nature-based improvements may exist even if it is not yet visible in how schools market themselves.

Reasons for limited natural integration

The most informative item concerned the reason that natural features are limited. As Table 3 shows, 53.4 per cent of respondents pointed to a lack of awareness or understanding of the benefits of natural elements in school design. Limited resources or budget constraints, which are often assumed to be the main obstacle, were chosen by 37.9 per cent. Only 8.6 per cent said

the repurposed or makeshift nature of the setup itself made it difficult tinclude natural features.

Table 3.

Perceived reasons for limited natural integration

Main reason for limited natural integration	Share of respondents	Rank
Lack of awareness or understanding of benefits	53.4%	1
Limited resources or budget constraints	37.9%	2
Repurposed or makeshift setup	8.6%	3

Two points follow. First, awareness stands out as a barrier, which means that decision makers in schools may not yet see natural features as part of educational quality. Second, the small share who blamed the building type suggests that respondents do not regard repurposed premises as incompatible with biophilic design, which is an encouraging finding for the strategies proposed later.

Structural challenges from field observation

Field notes pointed to three physical constraints that recurred across the schools: structural and material constraints, financial and resource limitations, and space scarcity. Converted houses have load-bearing walls and fixed openings that cannot be enlarged without structural advice, and materials for adaptation are chosen on cost and availability. Money for improvements competes with salaries, rent and utilities. Space is divided so tightly between teaching rooms, offices and circulation that there is little left for planting, courtyards or seating outdoors. Owners who rent their premises also hesitate to invest in a building that they do not control and might have to leave.

Ishikawa analysis of the challenges

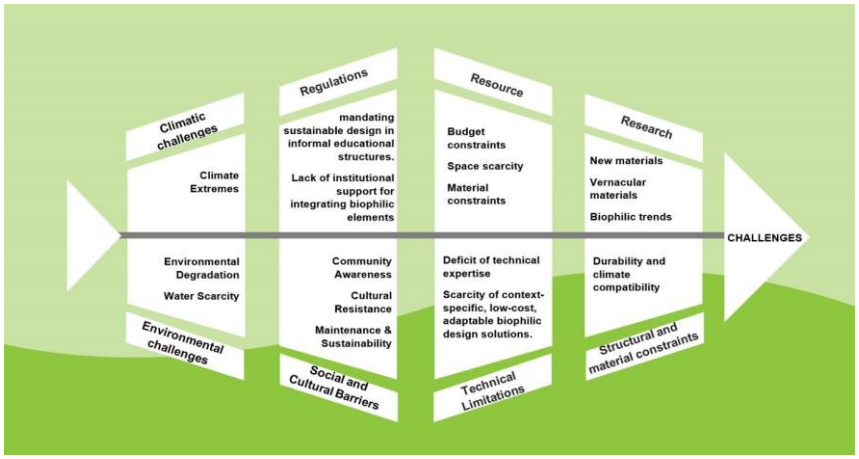
The qualitative themes were arranged in an Ishikawa diagram with the limited adoption of biophilic design as the central effect. Four main categories of challenge were identified, summarised in Table 4.

Table 4.

Categories of barriers to biophilic design in repurposed schools

Category	Main challenges	Typical examples in the field
Social and cultural barriers	Community awareness, cultural resistance, maintenance and sustainability	Plants regarded as untidy or hard to look after; no one assigned to upkeep
Environmental and climatic challenges	Climate extremes, environmental degradation, water scarcity	Heat that dries out plants; limited water for irrigation
Technical and design limitations	Deficit of technical expertise; scarcity of context-specific, low-cost, adaptable biophilic solutions	Owners unsure who to approach; ready-made solutions designed for large institutions
Policy and regulatory barriers	No mandate for sustainable design in informal educational structures; lack of institutional support for biophilic elements in makeshift settings	Regulations focus on safety and enrolment rather than environmental quality

The diagram also links the categories to related areas of action. Regulation connects to the need for policy mandates, resource constraints to budget, space and material limits, and research to new materials, vernacular materials and current trends in biophilic design. These links suggest that the barriers do not act separately. A teacher who values daylight may still be unable to act if the owner lacks technical advice, the climate makes planting difficult, and no regulation asks for improvement.



Fishbone diagram helps organize the factors that make it challenging to introduce biophilic design elements into repurposed schools. The main "spine" represents the challenge, while its branches show contributing causes, such as research gaps, structural constraints, technical limitations, budget and maintenance concerns, and limited awareness among users. For example, existing layouts may restrict daylight or ventilation upgrades, while limited technical knowledge can make it difficult to select suitable natural materials, ergonomic furniture, or sound features. By showing how these factors connect, the diagram helps identify the key barriers that should be addressed during planning and design.

Discussion

The most striking pattern in the data is the distance between what stakeholders believe and what their classrooms provide. More than nine in ten respondents think that nature supports well-being, and a majority prefer nature-rich classrooms to high-tech ones, yet fewer than one in four say that most classrooms in their school have good natural light or greenery. This agreement with the existing literature is not accidental. The attention restoration perspective of Kaplan (1995) and the stress-reduction findings summarised by Browning, Ryan and Clancy (2014) suggest that people have an intuitive sense of what restores them, and the respondents' reports of stress when nature is absent fit this idea. What the findings add is evidence from a setting where this intuition meets hard practical limits.

It is also interesting that the preference for daylight and views over technology appeared in a city where schools frequently promote digital facilities. This does not mean that technology is unimportant. It suggests that people see the basic conditions of light, air and outlook as foundational, something that equipment cannot compensate for. For designers, it is a reminder

that a low-cost improvement to a window or a classroom wall may deliver more of what users want than an additional device.

Respondents named lack of awareness more often than lack of money. This challenges the common assumption that cost is the single greatest obstacle. Budget certainly matters, as 37.9 per cent confirmed, but if owners, parents and administrators do not see natural features as part of educational quality, they will not allocate even a small budget for them. The implication is that awareness campaigns, demonstration projects and clear evidence may be as important as funding. Teachers and students, who in this sample are already convinced of the benefits, could be the most credible advocates within their own institutions, and designers could use the same channel to explain simple measures to school owners.

Only a small proportion of respondents blamed the makeshift setup itself. This supports an optimistic reading of the context. Residential buildings often have features that are favourable for biophilic design: courtyards, balconies, rooftops, small gardens, and windows that can be cleaned, widened or shaded. The problem lies less in the building type than in the way these features are currently used. At the same time, the observations about space scarcity, structural limits and tenancy uncertainty show that solutions need to be reversible, light and inexpensive. A permanent landscaped garden is unrealistic for a rented house; a movable planter system, a green screen on a balcony or a reflective surface that pushes light deeper into a room is not.

The Ishikawa analysis shows that the four categories of barriers reinforce one another. Cultural attitudes to maintenance affect whether plants survive, climate and water scarcity affect which species and systems are suitable, a lack of technical expertise makes it hard to choose between them, and the absence of policy means that none of these problems receives institutional attention. Solving one category alone is unlikely to be enough. A subsidy for plants without guidance on drought-tolerant species and on who will tend them may waste resources, and a regulation without technical support may be ignored. This integrated view is the main practical contribution of the study, because it helps stakeholders decide which actors need to be involved in each step.

Based on the findings, the paper proposes three broad strategies. The first is to develop low-cost, modular biophilic solutions suited to temporary and semi-permanent structures. Four patterns from the Browning framework seem especially suitable because they depend more on arrangement than on construction. Visual connection with nature can be improved by clearing

window obstructions, repositioning desks, and placing plants where they can be seen. Biomorphic forms and patterns can be introduced through wall graphics, textiles and furniture shapes drawn from natural geometry. Dynamic and diffuse light can be encouraged by using light-coloured finishes, translucent screens and mirrors to carry daylight into deeper rooms. Complexity and order can be added through natural materials, such as wood and stone finishes or fractal-inspired patterns, that give the eye interest without clutter.

The second strategy is to raise awareness through community and stakeholder engagement. Short workshops for school owners and teachers, simple visual guides in Urdu and English, and pilot classrooms that demonstrate the effect of small changes could convert the strong personal beliefs documented here into institutional action. The third is to advocate for policy frameworks that support sustainable, informal educational infrastructure. This could include guidance on environmental quality for converted school buildings, recognition of nature-based features in school registration or assessment, and links to existing sustainability programmes.

Limitations and future research

The study has limitations that readers should keep in mind. The sample of 58 responses was obtained through convenience and purposive sampling and is not representative of all schools in Karachi. The questionnaire used three-option closed items, which gave clear results but little room for nuance. Respondents' reports of mood are self-reported and were not verified against physiological or academic measures. The qualitative component relied on field notes rather than recorded and transcribed interviews. Future research could use larger and randomised samples, compare repurposed and purpose-built schools, measure daylight and indoor air quality directly, and test modular biophilic interventions in pilot classrooms to see whether the benefits reported in other countries appear in this context.

Conclusion

This study set out to understand why biophilic design is rare in repurposed schools in Karachi, and what the people who use these schools think of it. The answer is that the obstacles are real but not mainly physical. Teachers, students and designers overwhelmingly believe that natural light, greenery and views improve well-being, and most would choose a nature-rich classroom over a purely technological one. What holds schools back is a combination of limited awareness, tight budgets, scarce space, climatic stress, a shortage of technical advice adapted to small buildings, and the absence of any policy that asks for environmental quality in informal schools.

Because awareness was named more often than cost, there is room for progress through education and demonstration, and because the makeshift building was rarely blamed, flexible low-cost interventions appear feasible. By combining modular design solutions, stakeholder engagement and supportive policy, Karachi's improvised schools could become healthier and more inspiring places in which to learn.

Recommendations

Implementing biophilic design can be difficult when designers and stakeholders are conversant with only a limited range of basic elements, such as indoor plants or natural materials. The following recommendations address the identified challenges:

1. Broaden awareness beyond basic elements, materials and their availability. Provide training and practical guidance for designers, clients, building managers, and decision-makers on the range of biophilic strategies, through curriculum upgradation and short training sessions for school owners and managers.

2. Assess structural and technical constraints early. Before selecting features such as green walls, roof gardens, water elements, or large openings, assess load capacity, waterproofing, drainage, fire safety, ventilation, daylight control, and

maintenance access. Where major modifications are not feasible, use alternatives that fit the existing building—for example, views of nature, nature-inspired patterns, or small- scale planting.

3. Policymakers, planning authorities, and institutions can include biophilic design principles in building guidelines, public procurement criteria, design briefs, and sustainability frameworks. Clear guidance and measurable criteria can help make biophilic considerations a routine part of projects rather than an optional addition.

4. Plan for costs and long-term maintenance. Evaluate whole-life costs, not only initial installation expenses. Set realistic budgets, assign maintenance responsibilities, and select features that can be properly cared for. When resources are limited, prioritize context-appropriate strategies with manageable upkeep.

5. Use phased implementation and pilot projects. Test selected strategies in one area or through a small project before applying them more widely. Pilot projects can reveal technical, user, and maintenance issues and help build evidence and support for future investment.

6. Monitor outcomes and share lessons. Use post-occupancy feedback and building-performance data to assess how well biophilic features function. Share successful approaches, challenges, and maintenance lessons with design teams and policymakers to improve future projects.

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