



The effect of biophilic architecture on teachers' work stress and psychological well-being: A study at SMAN 1 Maumere

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ABSTRACT

This study aims to analyze the influence of biophilic architecture on psychological well-being, analyze the influence of psychological well-being on work stress, analyze the influence of biophilic architecture on work stress and examine the role of psychological well-being as a mediating variable in the relationship between biophilic architecture and teacher work stress at SMAN I Maumere. The data analysis technique used SEM PLS. The results of the analysis show that biophilic architecture has a significant influence on psychological well-being and teacher work stress at SMAN I Maumere. Psychological well-being is proven to have a negative effect on teacher work stress. Psychological well-being plays a significant mediating variable in the relationship between biophilic architecture and teacher work stress. This proves that the application of biophilic design principles not only has a direct impact on reducing stress, but also provides an indirect effect through increasing psychological well-being.

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1. INTRODUCTION

Teaching is a strategic profession in developing superior human resources. They bear the immense responsibility of transferring knowledge, shaping character, and developing the competencies of the younger generation. However, despite this noble role, teachers often face significant work challenges. Administrative pressures, a demanding curriculum, and expectations from students, parents, and the community can all lead to serious work stress. Teacher job stress is no small issue. A 2024 RAND Corporation report indicates that globally, approximately 73% of teachers experience job-related stress, 59% face burnout, and 28% even experience symptoms of depression. This situation demonstrates that job stress not only impacts individual teachers but can also impact the quality of learning and student achievement. Teachers who experience excessive stress tend to lack focus, fatigue easily, and reduce teaching effectiveness.

Psychologically, occupational stress arises when job demands exceed an individual's coping capacity (Cohen et al., 1983). In the context of teachers, stress can stem from the burden of teaching hours, ongoing evaluation, complex administration, and the physical condition of the school environment. According to Gaol (2021), school work environment factors are a significant factor influencing teacher stress levels. This finding is confirmed by Luma et al. (2018), who found that classroom conditions, including lighting, ventilation, and noise, significantly correlate with teacher stress levels in elementary schools. Research by Priliana et al. (2023) on elementary school teachers showed that poor or poorly maintained work environments, particularly in terms of overcrowding, thermal discomfort, and inadequate facilities, were significantly associated with

higher levels of occupational stress. In the long term, poor school environmental quality may have serious implications for teachers' psychological well-being. Continuous exposure to uncomfortable thermal conditions, excessive noise, inadequate lighting, and poor air circulation can contribute to chronic stress, emotional exhaustion, burnout, decreased job satisfaction, and even symptoms of anxiety and depression. Prolonged psychological strain may also reduce teachers' motivation, work performance, interpersonal relationships, and overall quality of life. Furthermore, unhealthy school environments may increase absenteeism and teacher turnover, which can negatively affect the sustainability and quality of educational processes (Fisher, 2024; Gray & Downie, 2024).

Besides work stress, another equally important aspect is teacher psychological well-being. According to Ryff (1989), psychological well-being encompasses six main dimensions: self-acceptance, positive relationships with others, autonomy, environmental mastery, purpose in life, and personal growth. Teachers with high levels of psychological well-being are better able to cope with work pressure, maintain motivation, and perform their duties optimally. Yosindra & Sakariah (2024) emphasized that psychological well-being is a protective factor that can reduce the negative impact of work stress, thereby maintaining teachers' long-term mental health.

The physical environment of a school plays a significant role in shaping teachers' psychological well-being. Hot room temperatures, inadequate lighting, poor ventilation, and high noise levels can exacerbate discomfort and increase psychological stress. Research by Da Mendez & Tandafatu (2024) in schools in a dry tropical climate demonstrated that classroom thermal comfort significantly impacts teachers' work stress levels. This means that the physical condition of a school not only impacts students but also significantly determines teachers' work comfort. To address these issues, the biophilic architectural approach emerged, a building design concept that integrates natural elements into the built environment. Kellert et al. (2011) state that biophilic design encompasses the use of natural lighting, vegetation, natural materials, cross-ventilation, and visual connectivity to nature. This design has been shown to improve mental health, reduce stress, and enhance productivity. Gultom et al. (2024) adds that the application of biophilic design in educational spaces has a positive impact on the behavior, psychological comfort, and motivation of users.

Several studies support this claim. Yin et al. (2020) found that exposure to biophilic indoor environments effectively reduces anxiety and accelerates stress recovery. Determan et al. (2019) demonstrated that learning spaces with biophilic elements can improve students' motivation, concentration, and academic success. In Indonesia, research by Nuha et al. (2023) demonstrated that implementing biophilic design in nature schools can create a more comfortable learning environment, not only for students but also for teachers. SMAN 1 Maumere, located in Sikka Regency, East Nusa Tenggara, is located in an area with a dry tropical climate. Relatively high air temperatures, low humidity, and limited green vegetation make the school's physical condition vulnerable to thermal discomfort for teachers. Previous studies on biophilic architecture in school environments still show several gaps. Barrett et al. (2015) and Determan et al. (2019) mainly focused on students' learning performance and classroom comfort, while research examining teachers' work stress and psychological well-being remains limited. Yin et al. (2020) and Gillis & Gatersleben (2015) discussed the psychological benefits of biophilic environments in general buildings, but not specifically in school settings. Furthermore, Fisher (2024) emphasized that empirical studies on biophilic schools in tropical climates are still scarce. Previous research also rarely integrates objective environmental measurements such as thermal comfort, lighting, and noise with psychological variables using quantitative models such.

Based on this description, it is clear that there is a close relationship between biophilic architecture, work stress, and teacher psychological well-being. However, studies on this topic in the context of high schools in dry tropical climates, such as SMAN 1 Maumere, are still very limited. Therefore, this research is crucial.

2. RESEARCH METHOD

Type and Design of Research

This research is a quantitative explanatory study using the Partial Least Squares – Structural Equation Modeling (PLS-SEM) approach. This research design was used to analyze the

influence of biophilic architecture on work stress and teacher psychological well-being, as well as to test the role of psychological well-being as a mediating variable.

Population and Sample

Population: All teachers at SMAN 1 Maumere. Sample: A total of 73 teachers, determined using the total sampling technique because the population size was relatively small so that the entire population could be used as respondents. Sample characteristics: permanent and honorary teachers who are actively teaching in the current academic year. The study used a total sampling technique because the population of teachers at SMAN 1 Maumere was relatively small, consisting of only 73 teachers. Therefore, all members of the population were included as respondents to obtain more comprehensive and representative data. Total sampling minimizes sampling bias and increases the accuracy of the findings because it reflects the actual conditions of the entire teacher population in the school. The sample size of 73 respondents has methodological implications for the robustness of the structural model. However, the use of Partial Least Squares–Structural Equation Modeling (PLS-SEM) is considered appropriate because this method is specifically designed to handle relatively small sample sizes and non-normal data distributions (Hair et al., 2021). In addition, the sample size has met the minimum requirement based on the “10-times rule,” where the number of samples should be at least ten times the largest number of structural paths directed at a latent construct in the model.

Research Instruments

- a. Physical Environment Measurement (PMV and Noise). Air temperature & humidity: measured with a thermo-hygrometer. Lighting: measured with a lux meter. Air speed: measured with an anemometer. Noise: measured with a sound level meter. Physical environmental data is used to calculate the Predicted Mean Vote (PMV) as an indicator of thermal comfort. PMV values are categorized as follows: Comfortable: PMV 0 ± 0.5 Slightly warm: +1 to +2 Heat: $\geq +3$ Noise compared to SNI 03-6386-2016 standard (≤ 55 dB for classrooms).
- b. Questionnaire, the questionnaire instrument uses a Likert scale of 1–5 (strongly disagree–strongly agree). Biophilic Architecture (X): adapted from Kellert's (2011) indicators, including natural lighting, vegetation, ventilation, natural materials, and visual connectivity with nature. Psychological Well-being (M): measured by the Ryff (1989) scale which includes self-acceptance, positive relationships, autonomy, environmental mastery, purpose in life, and personal growth. Job Stress (Y): measured using an adaptation of the Perceived Stress Scale (Cohen, 1983), including feelings of stress, emotional exhaustion, and control over work.

Data Analysis Techniques

Data analysis was carried out using SmartPLS version 4.0, through the following stages: a) Evaluation of Measurement Model (Outer Model): Convergent validity test (Outer Loading ≥ 0.70 ; AVE ≥ 0.50), Discriminant validity test (Cross Loading and Fornell-Larcker Criterion), Reliability test (CR ≥ 0.70 ; Cronbach's Alpha ≥ 0.70); b) Structural Model Evaluation (Inner Model): Test the R^2 value to see the contribution of the independent variable, Path coefficient test to see the influence between variables, Test t-statistics and p-value for significance of relationship; c) Mediation Test: Using Specific Indirect Effect analysis in PLS-SEM to test whether psychological well-being mediates the relationship between biophilic architecture and work stress.

3. RESULTS AND DISCUSSIONS

3.1. Results

Results of School Physical Environment Measurements

The results of physical environmental measurements at SMAN I Maumere show that classroom conditions are in the hot and humid category, outside the thermal comfort standards according to SNI 03-6572-2001: a) Class XI H, the air temperature was recorded at 28.7°C, with a relative humidity of 68.1%, and a noise level of 74 dB. The relative illuminance value of 0.8860 per 20,000 lux indicates that natural lighting is not optimal; b) Class XI F, the air temperature was recorded at 28.7°C, with a relative humidity of 71.2%. Illumination was only 0.07 lux, far below the standard of 300–500 lux according to SNI 6197:2011. These conditions have the potential to cause visual discomfort and increase fatigue; c) Field, the outdoor temperature reached 30.2°C, which

indicates that the dry tropical climate conditions in Maumere are indeed quite hot and have a direct impact on classroom conditions. Compared to standards, the ideal classroom temperature should be between 24–26°C with 40–60% humidity. This means that an average classroom temperature of 28–29°C with humidity >68% is considered warm. Based on the Predicted Mean Vote (PMV) scale, this condition can be categorized as +1 to +2, indicating thermal discomfort for the room's occupants. Furthermore, the noise level, which reached 74 dB, is well above the acoustic comfort standard for classrooms, according to SNI 03-6386-2016, which is ≤55 dB. These high noise levels have the potential to increase teacher work stress by disrupting concentration, complicating communication, and adding to psychological burdens.

Meanwhile, the lighting in class XI F, at only 0.07 lux, is far below the standard classroom lighting level (300–500 lux). This indicates uneven light distribution across several classrooms, which can impact eye health and reduce teacher comfort during the teaching and learning process.

Table 1. Evaluation of measurement model (outer model)

Construct	AVE	Cronbach's Alpha	Composite Reliability	Convergent Validity Statement
Psychological Well-being (PM)	0.889	0.975	0.980	Valid (Outer loading ≥ 0.70)
Biophilic Environment (LB)	0.841	0.968	0.974	Valid (Outer loading ≥ 0.70)
Job Stress (SK)	0.873	0.976	0.980	Valid (Outer loading ≥ 0.70)

Convergent Validity Test

Convergent validity is evaluated based on the outer loading value and Average Variance Extracted (AVE). All indicators have outer loading values ≥ 0.70, ranging from 0.798 to 0.953. The AVE values for all constructs also meet the criteria: a) Psychological Well-being (KP) = 0.889; b) Biophilic Environment (LB) = 0.841; c) Job Stress (SK) = 0.873. This value shows that the indicator can explain more than 50% of the construct variance, so that convergent validity is met.

Discriminant Validity Test

Discriminant validity was tested using Cross Loading and Fornell-Larcker Criterion. In cross loading, each indicator has the largest loading on its respective construct compared to other constructs, which indicates good construct separation. The Fornell-Larcker Criterion results show that the square root of the AVE (diagonal value) is higher than the correlation between constructs. For example, the diagonal value for KP (0.943) is higher than the correlation between KP-LB (0.957) and KP-SK (0.939), as well as for LB and SK. Thus, discriminant validity is met.

Reliability Test

Construct reliability was assessed through Composite Reliability (CR) and Cronbach's Alpha (CA).

Table 2. Cronbach's alpha and composite reliability

Variable	Cronbach's Alpha	Composite Reliability
KP	0.975	0.980
LB	0.968	0.974
SK	0.976	0.980

All values are above 0.70, indicating very good construct reliability.

Table 3. Structural model evaluation (inner model)

Relationship between variables	Path Coefficient (β)	T-Statistics	P-Value	Information
KP → SK	0.473	3.919	0.000	Significant
LB → KP	0.930	55.069	0.000	Significant
LB → SK	0.476	4.027	0.000	Significant

R² value

The R² value is used to see how much the independent variable contributes to the dependent variable. R² KP = 0.865, the variability of psychological well-being is explained 86.5% by the biophilic environment. R² SK = 0.871, variability in work stress is explained 87.1% by the biophilic environment and psychological well-being. This value is considered strong, indicating that the structural model has high explanatory power.

Table 4. Path coefficient, t-statistic, and p-value

Relationship between variables	Original Sample	T-Statistics	P-Value	Information
KP → SK	0.473	3.919	0.000	Significant
LB → KP	0.930	55.069	0.000	Significant
LB → SK	0.476	4.027	0.000	Significant

All paths have a t value > 1.96 and p < 0.05, which means they have a significant effect.

Table 5. Mediation test results (specific indirect effect)

Mediation Path	Original Sample	T-Statistics	P-Value	Information
LB → KP → SK	0.440	3,901	0,000	Significant mediation

The t value = 3.901 and p = 0.000 indicate that the mediation effect is significant, meaning that psychological well-being significantly mediates the influence of the biophilic environment on teacher work stress.

3.2. Discussion

The Influence of Biophilic Architecture on Teachers' Psychological Well-being

The results of the PLS-SEM analysis show that biophilic architecture has a significant effect on the psychological well-being of teachers at SMAN I Maumere, with a path coefficient value of 0.930, a T-statistic of 55.069, and a p-value of 0.000. This value indicates that the application of biophilic design principles has a very strong influence on improving psychological well-being. This finding aligns with the Biophilic Design theory (Kellert, 2008), which emphasizes that the integration of natural elements, such as natural lighting, cross-ventilation, vegetation, and natural materials, can create a restorative spatial experience. It is also consistent with Ulrich (1984), who suggested that exposure to natural environments can accelerate recovery from psychological stress and improve an individual's mental well-being. Physical environment measurement data supports these findings. Classroom temperatures ranged from 28.7°C with 68–71% humidity, a noise level of 74 dB, and suboptimal lighting. These conditions suggest that improving the quality of the physical environment through a biophilic approach is highly relevant for supporting teacher psychological well-being.

These findings are supported by Gillis & Gatersleben (2015), who found that exposure to natural elements in the workplace significantly contributes to stress reduction and emotional well-being. Similarly, Yin et al. (2018) demonstrated that indoor biophilic interventions promote psychological recovery and reduce mental fatigue among building occupants. In educational settings, Barrett et al. (2015) also emphasized that environmental quality, including natural lighting and ventilation, substantially influences human comfort, mood, and cognitive performance. Therefore, this study provides additional empirical evidence that biophilic architecture is an effective strategy for improving psychological well-being among teachers in tropical educational settings such as Maumere. The results of this study support those of Li et al. (2025) and Zafar et al. (2025) who stated that biophilic design in school environments, such as classrooms with natural light, greenery, and indoor plants, significantly improves the psychological well-being of students and teachers and reduces perceived stress.

The Influence of Psychological Well-being on Teachers' Work Stress

The analysis results show that psychological well-being has a significant effect on teacher work stress, with a path coefficient of 0.473, a t-statistic of 3.919, and a p-value of 0.000. This means that the higher the level of psychological well-being of teachers, the lower the level of work stress they experience. These findings support Ryff (1989) theory of psychological well-being, which encompasses six important dimensions: self-acceptance, positive relationships with others, autonomy, environmental mastery, purpose in life, and personal growth. Teachers with high psychological well-being are better able to adapt to work pressures, have strong intrinsic motivation, and demonstrate resilience to job demands.

In educational settings, job stress is often associated with high teaching workloads, curriculum changes, administrative duties, student behavior issues, and the pressures of

performance evaluations. Teachers who lack psychological well-being may experience emotional exhaustion, anxiety, irritability, and decreased job satisfaction. Conversely, teachers with positive psychological well-being are generally more adaptable and demonstrate stronger emotion regulation. They tend to have greater confidence in handling classroom challenges, maintain constructive interpersonal communication, and recover more quickly from work-related stress. These conditions ultimately contribute to lower stress intensity and healthier job functioning. This research supports Aulén et al. (2021) who found that teachers with higher psychological well-being reported lower levels of stress and burnout. Similarly, Collie et al. (2012) showed that teachers' psychological resources significantly influence their ability to cope with workplace demands and maintain professional effectiveness. Research by Hascher & Waber (2021) revealed that psychological well-being positively contributes to emotional resilience, work engagement, and stress management among educators.

The Influence of Biophilic Architecture on Teachers' Work Stress

Biophilic architecture was also shown to have a significant effect on teacher work stress, with a path coefficient of 0.476, a T-statistic of 4.027, and a p-value of 0.000. These findings indicate that the better the implementation of biophilic design in the school environment, the lower the level of teacher work stress. A school environment with good natural lighting, adequate ventilation, cooling vegetation, and controlled noise levels can create a conducive work environment and reduce psychological stress. This is consistent with research by Browning et al. (2014), which found that implementing biophilic design can improve building user comfort, reduce stress, and boost work productivity. At SMAN 1 Maumere, the relatively high room temperature and suboptimal lighting indicate potential thermal stress. Optimizing biophilic design can improve physical conditions, thereby reducing teachers' stress burden during daily teaching activities.

Biophilic design can reduce stress, improve mood, and enhance cognitive performance, making it particularly relevant for educational environments like SMAN 1 Maumere. At SMAN 1 Maumere, relatively high indoor temperatures and suboptimal lighting indicate potential thermal stress, which can further exacerbate teachers' work stress. Optimizing biophilic design by increasing natural light penetration, providing shade vegetation, enhancing natural ventilation, and integrating interior plants can improve physical conditions, thereby reducing teachers' stress burden during daily teaching activities (Kalonica et al., 2019).

The Role of Psychological Well-being as a Mediating Variable

The Specific Indirect Effect analysis shows that psychological well-being significantly mediates the relationship between biophilic architecture and teacher work stress, with an indirect coefficient of 0.440, a T-statistic of 3.901, and a p-value of 0.000. These results indicate that the implementation of biophilic design not only directly reduces work stress but also improves teachers' psychological well-being. This means that a natural and comfortable school environment can enhance teachers' positive psychological well-being, which in turn reduces their work stress levels. These findings reinforce the idea that teachers' work stress management strategies should focus not only on individual approaches but also on improving the physical school environment through biophilic design principles. Thus, psychological well-being serves as a crucial mechanism linking the physical environment to teachers' mental health.

These findings reinforce the idea that teachers' work stress management strategies should focus not only on individual approaches (e.g., mindfulness, coping strategies) but also on improving the physical school environment through biophilic design principles. Several studies show that biophilic elements in educational and workplace settings can reduce psychological strain, improve mood, and support mental recovery, thereby strengthening psychological well-being as a buffer against occupational stress. Thus, psychological well-being serves as a crucial mechanism linking the physical environment to teachers' mental health, underscoring that ergonomic and biophilic school design are integral components of holistic teacher support systems (Tareke & Hercz, 2021).

In the context of SMAN 1 Maumere, these findings imply that improving the physical quality of the educational environment is crucial for supporting teacher mental health. Existing environmental conditions such as high indoor temperatures, inadequate lighting, and noise exposure can contribute to psychological discomfort and stress. By implementing biophilic design

strategies, including increased natural ventilation, increased greenery, optimized natural lighting, and environmentally responsive building layouts, schools can create environments that restore and strengthen teachers' psychological well-being. As a result, teachers tend to experience lower stress levels, better emotional regulation, and increased work engagement.

These study findings support Gillis & Gatersleben (2015) findings that biophilic environments positively influence psychological health and emotional recovery. Similarly, Yin et al. (2018) found that exposure to biophilic indoor environments improves cognitive function and psychological well-being. Furthermore, studies on occupational health consistently demonstrate that psychological well-being acts as a protective factor against stress and burnout among employees, including teachers. These empirical findings strengthen the conclusion that psychological well-being is an important mechanism through which biophilic architecture contributes to reducing teacher work stress.

Therefore, the findings of this study emphasize that stress management strategies in educational institutions should not only focus on individual psychological interventions but also consider improving the physical school environment. Creating environmentally friendly, comfortable, and nature-connected educational spaces can have long-term positive effects on teachers' mental health and well-being. By integrating biophilic architecture principles into school planning and management, educational institutions can foster healthier, more sustainable, and psychologically supportive work environments for teachers.

Implications for Educational Facility Planning in Dry Tropical Climates

The findings of this study have important implications for the planning and design of educational facilities in dry tropical climates such as Maumere. The study demonstrates that poor environmental conditions, including high indoor temperatures, excessive noise, inadequate lighting, and limited natural ventilation, significantly contribute to teachers' work stress and reduced psychological well-being. Therefore, school planning in dry tropical regions should prioritize environmental comfort as an essential component of educational quality and occupational health.

First, educational facilities should incorporate biophilic architectural principles that respond to local climatic conditions. This includes maximizing natural cross-ventilation, optimizing daylight penetration, integrating vegetation and shaded green spaces, and using natural materials with low heat absorption properties. These strategies can reduce thermal discomfort, improve indoor air quality, and create restorative learning environments that support teachers' mental health and productivity.

Second, the findings suggest that school buildings in dry tropical climates should be designed with passive environmental control systems rather than relying solely on mechanical cooling. Building orientation, roof design, wall insulation, window placement, and vegetation buffers should be carefully planned to minimize heat exposure and reduce noise levels. Such climate-responsive design approaches can improve long-term environmental sustainability while simultaneously enhancing teachers' psychological well-being.

Third, educational policymakers and school administrators should recognize that the physical school environment is not merely an infrastructure issue but also a psychological and occupational health concern. Investment in environmentally responsive school facilities may help reduce teacher stress, burnout, absenteeism, and turnover, while improving work engagement and teaching effectiveness. In the long term, healthier school environments can contribute to better educational outcomes and more sustainable teacher retention in challenging tropical climates.

Finally, this study highlights the importance of integrating biophilic and human-centered design principles into future educational facility planning standards, particularly in regions characterized by high temperatures and environmental stressors. School development policies should therefore include thermal comfort, acoustic comfort, natural lighting, and access to greenery as key indicators of educational facility quality.

4. CONCLUSION

This study shows that biophilic architecture has a significant influence on the psychological well-being and work stress of teachers at SMAN I Maumere. The results of the PLS-SEM analysis revealed that the implementation of biophilic elements such as natural lighting, cross-ventilation,

vegetation, and green open spaces was proven to significantly improve the psychological well-being of teachers ($\beta = 0.930$; $p = 0.000$).

Furthermore, psychological well-being was shown to have a negative effect on teacher job stress ($\beta = 0.473$; $p = 0.000$), indicating that teachers with better psychological well-being are better able to manage work pressure. Biophilic design also had a direct effect on reducing job stress ($\beta = 0.476$; $p = 0.000$), demonstrating the importance of the school's physical environment in supporting the mental health of educators.

Mediation analysis showed that psychological well-being acted as a significant mediating variable ($\beta = 0.440$; $p = 0.000$) in the relationship between biophilic architecture and teacher work stress. This proves that the application of biophilic design principles not only has a direct impact on stress reduction but also provides an indirect effect through improving psychological well-being.

Thus, it can be concluded that optimizing the physical school environment based on biophilic architecture is an effective and sustainable strategy for managing teacher work stress. A healthy, natural, and comfortable school environment can improve teachers' positive psychological well-being and support a more productive and high-quality learning process.

The findings of this study also provide important recommendations for local governments, particularly in regions with dry tropical climates such as East Nusa Tenggara. Local governments are encouraged to integrate biophilic architectural principles into educational facility planning and school infrastructure policies. This can be achieved through the development of school design guidelines that prioritize natural ventilation, optimal daylight access, vegetation coverage, shaded outdoor learning areas, thermal comfort, and environmentally responsive building materials.

In addition, local governments should allocate educational infrastructure budgets toward improving environmental quality in schools, especially in areas experiencing high temperatures and limited green spaces. Renovation and construction programs for school buildings should incorporate passive cooling systems, green open spaces, and noise reduction strategies to support teachers' and students' psychological well-being.

Local governments are also encouraged to collaborate with architects, environmental planners, public health experts, and educational institutions in developing sustainable and climate-responsive school facilities. Training and awareness programs regarding the benefits of biophilic environments for mental health and educational performance should be promoted among school stakeholders and policymakers.

In the long term, integrating biophilic principles into educational facilities may contribute to healthier learning environments, improved teacher retention, reduced occupational stress, enhanced educational quality, and greater environmental sustainability in tropical regions. Therefore, biophilic school design should be considered not only as an architectural approach but also as part of a broader public policy strategy for supporting educational and community well-being.

Future research is recommended to examine the effectiveness of biophilic architecture across different educational levels, such as elementary schools, junior high schools, universities, and vocational institutions, to determine whether its psychological and environmental benefits vary according to users' characteristics and learning contexts. Comparative studies across different geographical conditions, including humid tropical, dry tropical, urban, coastal, and highland areas, are also necessary to understand how climate and environmental factors influence the implementation and effectiveness of biophilic design. In addition, future studies should involve larger and more diverse samples, apply longitudinal approaches, and integrate objective environmental measurements with psychological and educational performance indicators to obtain more comprehensive findings.

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