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TRANSFORMATION OF ENVIRONMENTALLY FRIENDLY SCHOOLS THROUGH THE INTEGRATION OF GREEN TECHNOLOGIES AND SUSTAINABLE MATERIALS: A LITERATURE REVIEW

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ABSTRAK

The purpose of this research is to examine the influence of implementing green technology and sustainable materials in the development process of environmentally friendly schools and their impact on the learning environment and educational achievement. This study applies a qualitative Systematic Literature Review methodology. To systematically integrate the scientific literature, narrative synthesis and thematic analysis methods are employed. Based on the analysis results, it can be stated that green technology plays a highly important role in improving energy efficiency and indoor environmental quality, while sustainable materials provide a significant contribution to reducing environmental impacts throughout the building life cycle. The combination of these two elements is capable of enhancing thermal comfort, air quality, and natural lighting, which positively affect students' ability to concentrate, think critically, and support the creation of a more effective and healthier learning process. In this context, the research emphasizes the importance of an integrated approach in designing school buildings that simultaneously considers green technology and sustainable materials in order to create an environmentally friendly, sustainable educational environment that supports the improvement of students' learning quality.

ABSTRAK

Tujuan penelitian ini adalah untuk mengkaji pengaruh penerapan teknologi hijau dan material berkelanjutan dalam proses pengembangan sekolah ramah lingkungan serta dampaknya terhadap lingkungan belajar dan pencapaian pendidikan. Dalam penelitian ini digunakan metodologi Systematic Literature Review. Untuk mengintegrasikan literatur ilmiah secara sistematis, digunakan metode sintesis naratif dan analisis tematik. Berdasarkan hasil analisis, dapat dinyatakan bahwa teknologi hijau memiliki peranan yang sangat Berdasarkan hasil analisis, dapat dinyatakan bahwa teknologi hijau memiliki peranan yang sangat penting dalam meningkatkan efisiensi energi dan kualitas lingkungan dalam ruang, sedangkan material berkelanjutan memberikan dampak yang signifikan dalam mengurangi pengaruh lingkungan selama siklus hidup bangunan. Kombinasi kedua elemen tersebut mampu meningkatkan kenyamanan termal, kualitas udara, dan pencahayaan alami yang berdampak positif terhadap kemampuan siswa dalam berkonsentrasi, berpikir, serta mendukung terciptanya proses pembelajaran yang lebih efektif dan sehat. Dalam konteks ini, penelitian menegaskan pentingnya pendekatan terintegrasi dalam perancangan bangunan sekolah yang memperhatikan teknologi hijau dan material berkelanjutan secara bersamaan guna menciptakan lingkungan pendidikan yang ramah lingkungan, berkelanjutan, dan mendukung peningkatan kualitas belajar peserta didik.

Kata kunci: *Integrasi teknologi hijau, Material berkelanjutan, Sekolah ramah lingkungan, Kualitas lingkungan belajar, dan Hasil pendidikan.*

INTRODUCTION

The growth of the education sector is at present caught in a dilemma with respect to balancing between enhancing the quality of learning and sustaining environmental needs. The educational infrastructure, such as school buildings, has become an essential part as it not only creates learning environments but is responsible for the increase in the use of energy and creation of greenhouse gasses. Within the international context, the UN promotes the idea that educational facilities should be safe and sustainable in order to transform education systems (United Nations, 2015). As a result, schools should not be considered passive objects; instead, they should be seen as learning environments, which are adaptable, efficient, and focused on human well-being. The emergence of the idea of green schools is due to these requirements. This is not only about energy savings but also the consideration of ecological, social, and pedagogical parameters in architectural design and its use. The research shows that modern sustainable school buildings may be used as an effective medium for learning and helping students become environmentally literate (Cole & Hamilton, 2019). This means that buildings play not only a supportive role by providing places for studies but serve as educational tools themselves.

The effectiveness of the performance of school buildings will be determined by the connection between green technologies and the materials used in construction. With regards to the energy efficiency of school buildings, it is possible to ensure energy efficiency through the application of green technologies such as natural ventilation, energy efficient lighting through daylight and energy controls through sensors. Despite its benefits in saving energy costs, it has been found that if the energy efficiency of buildings is pursued at the expense of the integrative relationship between the environment and the user, indoor environmental quality will be adversely affected (Jain et al., 2020). On the contrary, the adoption of sustainable materials assumes an important position in minimizing environmental effects during all stages of construction. The use of locally available, recyclable, or energy-efficient materials could result in reducing the carbon footprint and achieving efficient use of resources. Also, recent studies have indicated that sustainable materials alongside BIM and IoT technology can help build performance (Vestfal & Seduikyte, 2024).

Moreover, there is strong evidence that indoor environmental quality (IEQ) plays an important role in the process of learning. IEQ includes such aspects as air quality, thermal comfort, lighting, and acoustic properties of a place. Based on systematic research, it is clear that poor environmental quality reduces the level of students' concentration and learning effectiveness, leading to lower academic results (Brink et al., 2020). Another conclusion from recent studies is that such factors as air quality and ventilation have a positive effect on cognitive functions and absence rates (Vakalis et al., 2021). Also, recent studies confirm that the physical classroom environment significantly influences multiple dimensions of learning capacity, including memory, focus, and analytical ability (Zhang et al., 2023).

In a broader sense, some studies found that IEQ factors not only had general effects but were also different in terms of the impacts they caused depending on the social and demographic background of students. This fact demonstrates the need to consider diversity among users of schools to ensure the highest possible efficiency (Zhang et al., 2021). Furthermore, some systematic reviews revealed a lack of certain regulations covering indoor environmental quality in educational buildings leading to the use of general guidelines for the construction of public facilities (Al Jumaili & Sabbagh, 2024). On the national level, the implementation of green building practices in schools and other similar institutions is in its early stages. This is evidenced by research conducted in Indonesia where the integration of

the principles of green building is limited to some specific elements like energy efficiency and air quality, but not technology and material (Ariani & Zulfiar, 2025). Moreover, another study conducted by Alfarisi & Tauhida (2024) demonstrates that the link between energy consumption and indoor environmental quality has not been fully utilized within the practice of designing educational institutions in Indonesia.

While there have been plenty of investigations on green technology and sustainable materials, few are complete and focus on both aspects at once in a unified analysis framework. The recent studies state that a more integrative approach is vital to eliminate the performance gap, which refers to the difference between intention and reality (Jain et al., 2020). In addition, the connection between building performance and educational outcomes is inadequately examined empirically. The majority of research continues to concentrate on technical aspects like energy efficiency and emissions, not making a direct link to learning outcomes. Nevertheless, evidence suggests that ideal learning settings have the potential to greatly improve learners motivation and academic success (Zhang et al., 2023; Brink et al., 2020).

Based on the review of literature done above, it is evident that there is a very big need for research on integrating green technologies and sustainable materials in school construction designs. It is necessary for the study to look at the relationship between the technical performance of buildings and the quality of learning environments as well as the educational performance. Thus, the Systematic Literature Review method is used in the current study. The aim of the current study is to examine the usefulness of incorporating green technologies and sustainable materials in school constructions towards improving the environmental performance of the buildings. This research will make a huge contribution to theoretical and practical aspects through laying the foundations for future research directions in developing sustainable schools.

METHODS

The research adopted a Systematic Literature Review (SLR) methodology, which focuses on the identification, assessment, and synthesis of scientific literature on the use of green technology and sustainable material in fostering environmentally friendly schools. The use of SLR allows for a systematic synthesis of literature that is comprehensive and reproducible, as well as the recognition of trends in findings and knowledge gaps (Snyder, 2019). In terms of application, this research makes use of literature review methodologies that involve not just summarizing previous studies' results but analyzing and synthesizing different concepts in order to construct an informed overview of the topic. Literature review is vital when it comes to pinpointing research progressions, evaluating current contributions, and formulating the conceptual model as a basis for future research (Branley et al., 2004). Moreover, this methodology involves critically analyzing past literature on the subject matter as a means of highlighting the significance of the topic and the contributions made by the study in advancing knowledge (Creswell & Creswell, 2017). In order to provide a more systematic and organized approach to conducting the research, this paper uses the PRISMA 2020 framework, comprising the following four steps: identification, screening, eligibility, and inclusion (Page et al., 2021). Such a strategy enables full transparency and traceability of the entire process of selecting the sources used in this research (Alzahrani, 2020).

RESULT AND DISCUSSION

Research result

Tabel 1. Extraction Results of 12 Articles

No	Name	Title	Result
1.	Emily Oldham & Hyojin Kim, USA (2020)	IEQ Field Investigation in High-Performance, Urban Elementary Schools	Ventilation performance and design of school buildings play important roles in determining indoor environmental quality (IEQ), especially in terms of temperature, air quality, and thermal comfort of students.
2.	Hyojin Lim, Sungho Tae, & Seungjun Roh, South Korea (2022)	Major Building Materials in Terms of Environmental Impact Evaluation of School Buildings in South Korea	Concrete and steel are among construction materials that cause high levels of carbon emissions; hence, selecting environmentally friendly materials can minimize the negative impact of school buildings on the environment.
3.	Permana, Dewi Larasati, Lily Tambunan, & Fauzan Alfi Agirachman, Indonesian (2023)	Evaluasi Kinerja Hijau Material Resources and Cycle (MRC) pada Bangunan Kayu Modular Prafabrikasi	Prefabrication and modularization using timber enhance sustainability by promoting material reuse and minimizing wastage during the process of construction..
4.	M. Haikal Kemal, Tri Wulan Sari, Dyah Nurwidyaningrum, Agung Budi Broto, Suhit, & M. Fahmi, Indonesian (2024)	Kajian Penilaian Sumber dan Siklus Material Gedung Sekolah Dasar X di Jakarta Selatan, Indonesia	Sustainability of school buildings will be improved through proper lifecycle management of construction materials used.
5.	Oktavi Elok Hapsari, Indonesian (2018)	Analisis Penerapan Green Building Pada Bangunan Pendidikan	Adoption of green building concepts through natural ventilation and use of daylighting and locally available materials such as bamboo lowers the consumption of energy and promotes healthiness of the learning environment.
6.	Ezzaddin Abdullah Al-Atesh, Yani Rahmawati, Noor Amila Abdullah Zawawi & Cristiono Utomo, Malaysian & Indonesian (2023)	A Decision-Making Model For Supporting Selection Of Green Building Materials	In addition, green material choices demand a decision-making model, which takes into account environmental, economical, and technical parameters for achieving the best result.
7.	Abdul Mohsin Ali & Shakuntala Acharya, Indian (2026)	Proposed IEQ Parameters Weighting Scheme For Naturally Ventilated School Classrooms In A Warm-Humid Climate	In humid-warm regions, natural ventilation is the key IEQ aspect determining humidity level, indoor temperature, and comfort of people in schoolrooms.
8.	Hyun-Ho Kang, Youn-Kyu Seo, & Won-Hwa Hong, South Korea (2016)	A Study on Analysis on Energy Usage and Economy of School	Buildings, which have received green building certification, feature energy efficiency as they use HVAC

		Facilities in Accordance with Green Building Certification	systems and effective lighting along with their economic advantages.
9.	Vincent Gbouna Zakka & Minhyun Lee, Global (2025)	An Integrated Design Of Energy And Indoor Environmental Quality Monitoring System For Effective Building Performance Management	IoT systems facilitate real-time observation of the environment and energy utilization in order to improve building management operations.
10.	F. Asdrubali, A. Fronzetti Colladon, L. Segneri, & D.M. Gandola, Global (2024)	LCA and energy efficiency in buildings: mapping more than twenty years of research	An approach which includes Life Cycle Assessment (LCA) and energy efficiency ensures a thorough investigation of environment in building life cycle process.
11.	Toderasc Mihai & Vlad Iordache, Global (2016)	Determining the Indoor Environment Quality for an Educational Building	Environmental quality is affected by the interplay between building design and energy performance, which affects ventilation, lighting, and insulation for creating comfort indoors.
12.	Holly T. Ferguson, Aimee. P. C. Buccellato, Samuel Paolucci, Na Yu, & Charles F. Vardeman II, USA (2016)	Green Scale Research Tool for Multi-Criteria and Multi-Metric Energy Analysis Performed During the Architectural Design Process	The application of multi-criteria decision support tools within the design process ensures an increased level of integration between the energy performance of the construction and its overall quality by using data-driven decision-making.

Discussion Results

In this study, the authors employed a narrative synthesis method combined with thematic analysis to present the findings from twelve articles. The synthesis began with the identification of topics that were consistently discussed, the identification of the variables analyzed, and the examination of the interconnections among these concepts across several studies.

Green Technology and School Building Performance

Green technology is considered an important factor in improving energy efficiency and indoor air quality in school buildings. Mechanical and natural ventilation systems have been identified as significant elements that help maintain air quality and thermal comfort levels. Oldham and Kim (2020) claim that schools that use performance-based ventilation systems experience higher stability in indoor air quality compared to conventional schools. Stable air quality helps minimize the risk of pollution and increases students' comfort levels while studying. Indeed, as demonstrated by Kang et al. (2016), the application of green construction principles in an educational context can lead to a significant reduction in energy usage through the optimization of lighting and ventilation systems. Not only does this approach save money, but it also leads to decreased emissions of carbon from educational buildings. With the development of technologies using digital technology, building systems have been

made even more efficient. According to Zakka and Lee (2025), monitoring systems powered by the Internet of Things can allow for the regulation of energy consumption and environment quality, thus making buildings responsive to changing environments. Nevertheless, the findings have also revealed that technologies do not act independently without any support. When used alongside passive design techniques and proper materials, their performance becomes much better.

Sustainable Materials and the Environmental Impact of School Buildings

Construction materials play an important role in the sustainability of buildings by affecting such things as carbon emissions and resource consumption. For instance, Lim et al. (2022) explain that the choice of materials has a direct bearing on the environmental impacts of school buildings, most notably during the manufacturing and construction stages. Such research findings support the claim that sustainability initiatives should start from the design stage. Life cycle assessment is an important tool for examining the impacts of building materials. As Kemal et al. (2025) illustrate, life cycle assessment of building materials reveals great potential for carbon emission reductions and improved energy efficiency in school buildings. This research finding demonstrates that materials affect not only construction but also operation of buildings. Concerning the implementation aspect, the use of indigenous and natural materials shows higher adaptability to the climate. For instance, Permana et al. (2023) indicate that the utilization of modular wood-based materials in nature schools improves building effectiveness and lowers wastage. Hapsari (2018) also confirms that bamboo can be considered as the major material in Green School Bali for a healthier and more sustainable educational environment.

Indoor Environmental Quality (IEQ) and Learning Performance

Indoor environmental quality (IEQ) is a key variable that links building performance with educational outcomes. The study conducted by Oldham and Kim (2020) reveals that proper indoor air quality ensures the comfort and wellbeing of students. This condition has implications for increased focus and decreased cognitive fatigue. The same is further emphasized by Ali and Acharya (2026) when they state that parameters like ventilation, temperature, and humidity have a huge impact on the academic results of the students. Moreover, Zhang et al. (2023) reveal that the physical environment of classroom, such as natural illumination and air quality, directly affect the ability of students to concentrate, memorize, and process information. Thus, it can be concluded that IEQ not only improves the comfort level of an individual, but also enhances his or her cognitive processes. However, Zhang et al. (2021) emphasize the importance of moderation of effects of IEQ by social and demographic characteristics in determining its effect on student performance. This proves the necessity of taking into account users' diversity when designing schools. In addition, IEQ could be used as a mediating variable between the two variables in relation to education. In other words, the technologies and materials will not affect student performance because it happens via IEQ. Oldham & Kim (2020) have also shown how better ventilation improves the comfort zone of students, thus improving their performance in class. On the other hand, Vakalis et al. (2021) argue that despite existing studies suggesting that there exists a positive correlation between green schools and academic achievement, consistent empirical data is yet to be gathered.

Integration of Technology, Materials, and Building Systems

The integration of green technologies and sustainable materials emerges as one of the key aspects which have not been explored widely. Majority of researches are still sector-based and fail to link various variables in a cohesive system. In their study, Al-Atesh et al. (2023) state that the choice of sustainable materials should be based on a multi-criteria approach which takes into account technical, financial, and environmental issues. Nevertheless, this research fails to establish a connection between materials selection and building technologies systems. In contrast, Asdrubali et al. (2024) stress that energy efficiency must be combined with materials lifecycle to ensure sustainable buildings. In addition, the correlation between materials and technology can be found from the correlation between thermal capacities of materials and the ventilation systems. High thermal capacities of materials will enable stability of temperatures inside buildings, making the work of air conditioning or ventilation less burdensome. In this situation, efficiency of technologies employed will heavily rely on the quality of the materials employed. This point becomes apparent from the study conducted by Lim et al. (2022), showing that building efficiency will depend directly on the selected material. Ferguson et al. (2016) provide an energy analysis tool that facilitates integration in building designs. Nevertheless, the use of this energy analysis tool in school buildings is still lacking. This implies that despite the availability of tools that facilitate integration, there are no effective measures taken in this field.

CONCLUSION

The current study has empirically proven that the transition process of the green school is contingent upon the incorporation of green technologies and sustainable materials into a comprehensive building structure. On one hand, green technologies affect energy efficiency and the quality of the indoor environment. On the other hand, sustainable materials impact the reduction of the environmental footprint during the life cycle of a building. Both factors affect student well-being, physical condition, and cognitive performance that are integral elements of the learning quality. According to the literature review, the current scientific research still remains limited and does not establish the comprehensive connection between building technological processes and learning outcomes. Consequently, this study can be considered a theoretical contribution since it reinforces an integrative model for the interaction between technology, materials, environmental quality, and learning performance. Other aspects that the current research could develop are discussed in other directions for further research that should also be mentioned here. It may be helpful to conduct empirical researches based on field data, as this will allow quantifying the correlation between the level of integration of technology and materials and learning outcomes. Furthermore, it would be helpful to conduct simulations to form a conceptual model of interaction of certain factors.

REFERENCES

Al Jumaili, T., Sabbagh, M. (2024). Systematic review for the assessment of indoor environment quality factors and sub-indicators of classrooms. International Journal of Sustainable Development and Planning, Vol. 19, No. 8, pp. 3255-3263. https://doi.org/10.18280/ijsdp.190837

Al-Atesh, E. A., Rahmawati, Y., Zawawi, N. A. W. A., & Utomo, C. (2023). A decision-making model for supporting selection of green building materials. *International Journal of Construction Management*, *23*(5), 922–933.

https://doi.org/10.1080/15623599.2021.1944548

Alfarisi, S., & Tauhida, D. (2024). Green Campus: Analisis Konsumsi Energi Fosil Terhadap Indoor Environmental Quality. Journal of Industrial Engineering and Technology, 4(2), 195–204. https://doi.org/10.24176/jointech.v4i2.12536

Ali, A. M., & Acharya, S. (2026). Proposed IEQ parameters weighting scheme for naturally ventilated school classrooms in a warm-humid climate. Science and Technology for the Built Environment, 1–12. https://doi.org/10.1080/23744731.2026.2631347

Alzahrani, M. A. A. (2020). (PDF) Book Review: The Literature Review: Six Steps to Success, (3rd edition), by Lawrence A. Machi and Brenda T. McEvoy (2016). https://www.researchgate.net/publication/339032640_Book_Review_The_Literature_Review_Six_Steps_to_Success_3rd_edition_by_Lawrence_A_Machi_and_Brenda_T_McEvoy_2016

Ansori, A., & Wahyudin, D. (2020). Upaya Penurunan Emisi GRK Melalui Green Building. Jurnal Reformasi Administrasi: Jurnal Ilmiah Untuk Mewujudkan Masyarakat Madani, 7(1), 1–8.

Ariani, M., & Zulfiar, M. H. (2025). Evaluation of the implementation of the green building concept in mid-rise buildings. *DIMENSI: Journal of Architecture and Built Environment, 52*(2), 168–178. https://doi.org/10.9744/dimensi.52.2.168-178

Asdrubali, F., Fronzetti Colladon, A., Segneri, L., & Gandola, D. M. (2024). *LCA and energy efficiency in buildings: Mapping more than twenty years of research*. arXiv. https://doi.org/10.48550/arXiv.2409.00065

Benka-Coker, W., Young, B., Oliver, S., Schaeffer, J., Manning, D., Suter, J., Cross, J., & Magzamen, S. (2021). Sociodemographic variations in the association between indoor environmental quality in school buildings and student performance. *Building and Environment, 206*, Article 108390. https://doi.org/10.1016/j.buildenv.2021.108390

Branley, D., Seale, C., & Zacharias, T. (2004). Doing a literature review. Researching Society and Culture, 145–162.

Brereton, P., Kitchenham, B. A., Budgen, D., Turner, M., & Khalil, M. (2007). Lessons from applying the systematic literature review process within the software engineering domain. Journal of Systems and Software, 80(4), 571–583. https://doi.org/10.1016/j.jss.2006.07.009

Brink, H. W., Loomans, M. G. L. C., Mobach, M. P., & Kort, H. S. M. (2020). Classrooms' indoor environmental conditions affecting the academic achievement of students and teachers in higher education: A systematic literature review. *Indoor Air, 31*(2), 405–425. https://doi.org/10.1111/ina.12745

Cole, L. B., & Hamilton, E. M. (2020). Can a Green School Building Teach? A Pre- and Post-Occupancy Evaluation of a Teaching Green School Building. *Environment and Behavior, 52*(10), 1047-1078. https://doi.org/10.1177/0013916518825283

Creswell, J. W., & Creswell, J. D. (2017). Research design: Qualitative, quantitative, and mixed methods approaches. Sage publications.

Dinanti, H. A. P., Qonitan, F. D., & Ridhosari, B. (2023). Evaluasi Aspek Konservasi Air berdasarkan Prinsip Green Building (Studi Kasus Gedung Griya Legita, Universitas Pertamina). Journal of Sustainable Infrastructure, 2(2), 59–71. https://doi.org/10.61078/jsi.v2i2.21

Ferguson, H. T., Buccellato, A., Paolucci, S., Yu, N., & Vardeman II, C. F. (2016). *Green scale research tool for multi-criteria and multi-metric energy analysis performed during the architectural design process*. arXiv. https://arxiv.org/abs/1602.08463

Hapsari, O. elok. (2018). Analisis Penerapan Green Building Pada Bangunan Pendidikan (Studi Kasus : Green School Bali). Al-Ard: Jurnal Teknik Lingkungan, 3(2), 54–61. https://doi.org/10.29080/alard.v3i2.334

Jain, N., Burman, E., Robertson, C., Stamp, S., Shrubsole, C., Aletta, F., Barrett, E., Oberman, T., Kang, J., Raynham, P., Mumovic, D., & Davies, M. (2019). Building performance evaluation: Balancing energy and indoor environmental quality in a UK school building. *Building Services Engineering Research and Technology, 41*(3), 343–360. https://doi.org/10.1177/0143624419897397

Kang, H.-H., Seo, Y.-K., & Hong, W.-H. (2014). A study on analysis on energy usage and economy of school facilities in accordance with green building certification. *Journal of Asian Urban Environment, 2014*(1), 131–. https://doi.org/10.69457/aiue.20140027

Katiandagho, M., FD Sidabutar, Y., Yandi, D., Hendra Masfar, F., & Panusunan, P. (2025). Desain Bangunan Hijau Di Wilayah Kota Batam: Konsep, Implementasi, Dan Dampaknya Terhadap Perkotaan. Zona Sipil: Program Studi Teknik Sipil Universitas Batam, 15(1), 6–10. https://doi.org/10.37776/zs.v15i1.1691

Kemal, M., Pratama, R., & Sari, D. (2025). Kajian Penilaian Sumber dan Siklus Material Gedung Sekolah Dasar X di Jakarta Selatan, Indonesia. *Jurnal Teknik Sipil Institut Teknologi Padang*, *12*(1), 35-042. https://doi.org/10.21063/jts.2025.V1201.035-042

Khoshdelnezamiha, F., Tookey, J., & Sahab, M. H. (2020). A systematic review of green building rating tools. Journal of Building Engineering, 32, 101685. https://doi.org/10.1016/j.jobe.2020.101685

Li, Y., Zhang, X., Wang, H., & Chen, Z. (2024). Life cycle assessment in green building: A thorough review of tools and applications. Journal of Cleaner Production, 438, 140876. https://doi.org/10.1016/j.jclepro.2024.140876

Lim, H., Tae, S., & Roh, S. (2022). Major Building Materials in Terms of Environmental Impact Evaluation of School Buildings in South Korea. Buildings, 12(4), 498. https://doi.org/10.3390/buildings12040498

Ma, X., Liu, H., Zhang, Z., & Li, Y. (2023). How does indoor physical environment differentially affect learning performance in various classroom types? *Building and Environment, 234*, Article 110189. https://doi.org/10.1016/j.buildenv.2023.110189

Martín-Martín, A., Orduna-Malea, E., Thelwall, M., & Delgado López-Cózar, E. (2021). Google Scholar, Microsoft Academic, Scopus, Dimensions, Web of Science, and OpenCitations' COCI: A multidisciplinary comparison of coverage via citations. Scientometrics, 126, 871–906. https://doi.org/10.1007/s11192-020-03690-4

Mihai, T., & Iordache, V. (2016). Determining the indoor environment quality for an educational building. *Energy Procedia, 85*, 566–574. https://doi.org/10.1016/j.egypro.2015.12.246

Oldham, E., & Kim, H. (2020). IEQ Field Investigation in High-Performance, Urban Elementary Schools. Atmosphere, 11(1), 81. https://doi.org/10.3390/atmos11010081

Page, M. J., McKenzie, J. E., Bossuyt, P. M., et al. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ, 372, n71. https://doi.org/10.1136/bmj.n71

Permana, P., Larasati, D., Tambunan, L., Agirachman, F. A., Sabrina, J., Wardah, Z., & Salsabila, A. (2023). Evaluasi kinerja hijau material resources and cycle (MRC) pada bangunan kayu modular prafabrikasi: Studi kasus bangunan Sekolah Alam Bandung. Jurnal Arsitektur ARCADE, 7(2), 177–183. https://doi.org/10.31848/arcade.v7i2.3164

Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines.

Journal of Business Research, 104, 333–339. https://doi.org/10.1016/j.jbusres.2019.07.039

United Nations. (2015). *Transforming our world: The 2030 agenda for sustainable development*. https://sdgs.un.org/2030agenda

Vakalis, D., Lepine, C., MacLean, H. L., & Siegel, J. A. (2021). Can green schools influence academic performance? *Critical Reviews in Environmental Science and Technology*, *51*(13), 1354–1396. https://doi.org/10.1080/10643389.2020.1753631

Vestfal, P., & Seduikyte, L. (2024). Systematic Review of Factors Influencing Students' Performance in Educational Buildings: Focus on LCA, IoT, and BIM. Buildings, 14(7), 2007. https://doi.org/10.3390/buildings14072007

Wang, J., Abdul-Samad, Z., & Salleh, H. (2024). A systematic review of BIM adoption for green building life cycle management. Renewable and Sustainable Energy Reviews, 181, 113314. https://doi.org/10.1016/j.rser.2024.113314

Wolkoff, P. (2018). Indoor air humidity, air quality, and health – An overview. International Journal of Hygiene and Environmental Health, 221(3), 376–390. https://doi.org/10.1016/j.ijheh.2018.01.015

Yasinta, R. B., Pradana, M. A., & Dahlia. (2024). Analyzing Green Building of Appropriate Site Development Requirements in High Rise Building. Media Komunikasi Dan Pengembangan Teknik Lingkungan, 21(1), 132–143. https://doi.org/10.14710/mkptl.21.1.132-143

Yasinta, R. B., Pradana, M. A., & Dahlia. (2024). Analyzing Green Building of Appropriate Site Development Requirements in High Rise Building. Media Komunikasi Dan Pengembangan Teknik Lingkungan, 21(1), 132–143. https://doi.org/10.14710/mkptl.21.1.132-143

Zakka, V. G., & Lee, M. (2025). *An integrated design of energy and indoor environmental quality monitoring system for effective building performance management*. arXiv. https://doi.org/10.48550/arXiv.2503.23323

Zhu, Y., Wang, X., & Hu, J. (2024). AI applications for green building certification and compliance. Building and Environment, 241, 110670. https://doi.org/10.1016/j.buildenv.2023.110670