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To cite this article: M I Azizah *et al* 2025 *IOP Conf. Ser.: Earth Environ. Sci.* **1439** 012018

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Adaptable Biophilic Design for Informal Learning Spaces: Cultivating Comfort and Inspiration for Marginalized Communities

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Abstract. This study explores the application of biophilic design principles to informal learning spaces in Indonesia, with a focus on marginalized communities. While biophilic design has been extensively studied in formal educational settings, its potential in informal learning environments remains largely unexplored. This research addresses this gap by synthesizing biophilic design patterns, diverse learning styles, and contextual considerations of adaptability, affordability, and simplicity. Through a comprehensive literature review, analysis of existing informal learning spaces in Indonesia, and consideration of various learning modalities, we developed six key design criteria: (1) adaptable, simple spatial layouts; (2) natural sensory-stimulating elements; (3) affordable and low-maintenance nature elements; (4) cost-effective materials with calming natural colours and textures; (5) seamless indoor-outdoor connections; and (6) adjustable natural and artificial lighting and airflow. These criteria form a framework for creating nature-inspired, learner-centred environments that support diverse educational needs while respecting economic constraints. Our findings suggest that integrating biophilic design in informal learning spaces can enhance educational experiences for marginalized communities in Indonesia. This study contributes to the growing body of research on biophilic design in educational settings and provides practical guidelines for implementation in resource-limited contexts. Future research directions include broader exploration of non-formal learning environments, mixed-methods approaches for comprehensive evaluation, and investigation of long-term impacts on learning outcomes and well-being.

Keywords: Biophilic Design, Informal Learning Spaces, Adaptability, Marginalized Communities

1. Introduction

Biophilic design has emerged as a significant approach within architecture and urban planning, aiming to reconnect people with nature through design elements that reflect natural forms, patterns, and processes [1, 2]. Extensive studies highlight that biophilic environments can improve well-being, cognitive function, and overall quality of life [3]. In educational settings, biophilic design has been shown to foster engagement, reduce stress, and support academic

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performance, making it particularly beneficial for schools and universities [4]. These findings highlight the significance of nature-integrated places in promoting superior learning experiences, sparking interest in researching biophilic design across a variety of educational settings.

However, despite the demonstrated benefits of biophilic design in formal learning environments, such as schools and universities [5], there is a notable gap in research focusing on informal learning settings [6]. Informal learning spaces, ranging from community libraries to open-air educational centres, play a crucial role in communities yet remain understudied in terms of biophilic design. This research gap allows one to explore the possibility of biophilic design in improving informal learning environments where diverse learners often face different environmental, social, and resource-related challenges compared to formal educational settings.

Addressing this gap is particularly relevant for Indonesia, where marginalized communities rely heavily on informal learning spaces to provide educational resources and opportunities [7, 8]. In these settings, biophilic design could not only enrich the learning experience but also support the well-being of learners in underserved areas. By focusing on the design needs of informal learning spaces in Indonesian marginalized communities, this study seeks to provide insights into how biophilic principles can be tailored to diverse socio-cultural and geographical contexts, ultimately contributing to more inclusive and accessible learning environments.

2. Methodology

2.1 Study Design

This study employed an exploratory research-in-design approach to explore the application of biophilic concepts in informal learning spaces. First, a literature review was conducted to examine relevant studies on biophilic design in educational settings and diverse learning styles, providing a theoretical foundation for the research. Next, the Indonesian context, with some informal learning settings in marginalized communities, was carefully considered, recognizing this developing country's unique challenges and opportunities. The objectives were then established, focusing on offering informal learning spaces supported by biophilic concepts, with simplicity, affordability, and adaptability as key considerations. Finally, the process included synthesizing design concepts and illustrations to visualize the proposed design solutions.

2.2 Data Collection and Analysis

This study employed three data collection phases to inform the design approach. A review of biophilic design in educational settings literature was conducted to establish a theoretical foundation. Secondary data was also gathered to explore various learning styles, such as VARK Modalities and their relationship with learning environments. The PKBM cases in some regions in Indonesia were studied through website searches to perform a contextual analysis of informal learning spaces in Indonesia. To broaden the scope of case studies and enhance the validity of this research, the methodology will also include an analysis of various informal learning spaces across Indonesia. The selected case studies encompass a diverse range of learning environments, including Rumah Baca Ujungberung in Bandung, Taman Bacaan Pelangi in Flores, Kampung Dongeng in Ciputat, Sokola Rimba in Jambi, Rumah Singgah YKAI in Jakarta, and Saung Angklung Udjo in Bandung. This diverse selection aims to provide a comprehensive understanding of the needs and challenges in applying biophilic design within different social, cultural, and geographical contexts in Indonesia.

The data analysis for this study utilized a qualitative method. Thematic analysis was employed to examine qualitative data from the literature review, identifying recurring themes

related to biophilic design, educational settings, regional context, and learning style types. Comparative analysis was conducted to align findings from formal and informal educational settings, highlighting similarities and differences in their spatial characteristics. The contextual analysis involved studying informal learning spaces in Indonesia through cases study. Finally, the analysis results were synthesized to propose contextual informal learning space design concepts and illustrations of the implementations.

3. Results and Discussion

3.1 Reviewing Studies on Biophilic Design in Educational Environments

More than one decade's trend in academic publications shows a significant development in the attention of researchers to the topic of biophilic design (Fig. 1). Diverse fields of study, such as architectural engineering, computer science, psychology, geography, and sociology, are exploring this topic due to its importance in enhancing the quality of living spaces and the built environment (Fig. 2). While initially popular in urban living [9-14], healthcare facilities [15-21], and workplace design [22-28], biophilic applications have broadened to educational settings and learning spaces [29-33]. In these facilities, biophilic is considered a potential method to create more inspiring and comfortable environments that encourage learning, creativity, and overall well-being in students.

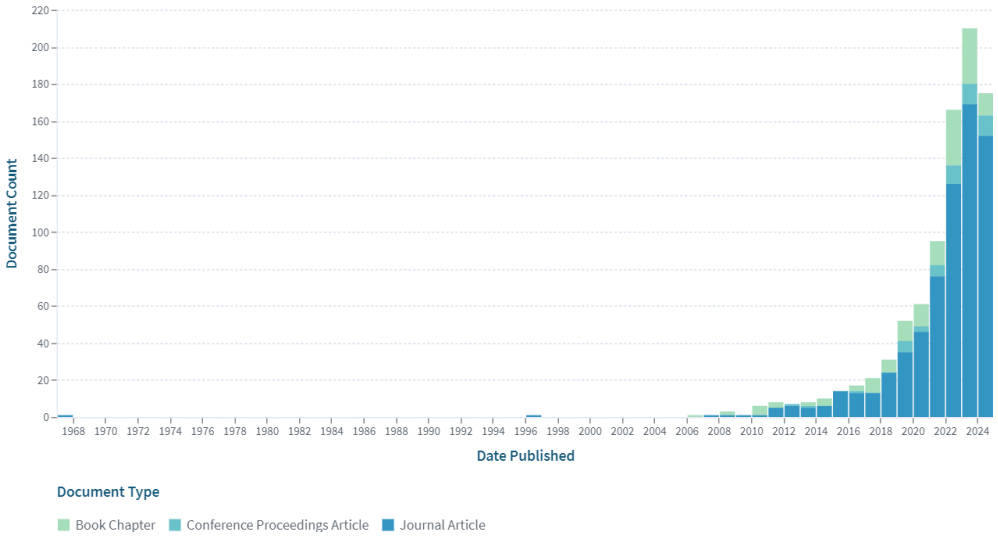

Figure 1. Publication documents count on the topic of biophilic design in educational spaces. Source: Lens.org [34], Scholarly works search results on biophilic design and biophilic architecture. Accessed on: September 30, 2024.

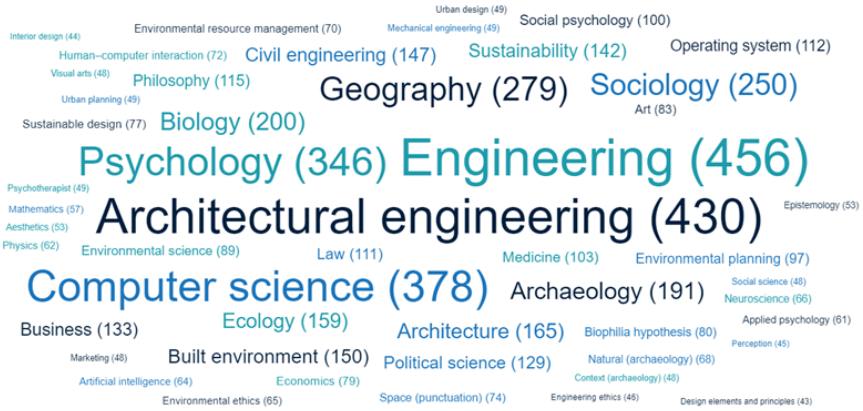

Figure 2. Fields of academic publications on the topic of biophilic design in educational spaces. Source: Lens.org [34], Scholarly works search results on biophilic design and biophilic architecture. Accessed on: September 30, 2024.

Biophilic design has been explored in educational settings under various themes, ranging from physical integration of nature to developing emotional and cognitive connections with the environment [29, 30]. One popular theme is the study of incorporating natural elements, such as vegetation, natural light, and fresh air, into learning spaces to create a more calming and stress-reducing environment [29, 32, 35]. Another studied theme is nature-based learning settings, which use outdoor classrooms and courtyards as learning spaces to provide students with direct experiences with nature [31]. There are studies in the use of sensory and spatial design that aim to strengthen students' connections to nature by incorporating natural forms, textures, and materials into the layout and design of educational spaces [31-33, 35]. These studies have demonstrated that biophilic strategies improve comfort and aesthetic appeal and enhance student focus, creativity, and cognitive functioning [33, 36-37]. These are key components in developing more holistic learning environments.

While the majority of studies on biophilic design have predominantly focused on formal educational settings, such as schools [29], campuses [30-32, 35], and universities [5, 33, 36, 38] with focus on students' restoration, connectedness, stress, mental health, and quality of life (Fig. 3), there has been relatively less attention given to its application in informal learning spaces such as transitional shelters, co-learning spaces, community centres, community libraries [39], and other types of spaces that encourage self-directed and co-learning activities. This gap highlights the need to explore how biophilic approach can support non-traditional learning environments.

Figure 3. Keywords from academic publications on the topic of biophilic design in educational spaces. Source: Lens.org [34], Scholarly works search results. Accessed on: September 30, 2024.

Informal learning is a fundamental process in human development that persists throughout one's entire life. The dynamics of society contribute to the increasing popularity of informal and non-formal learning as vital sources of knowledge and skills [40]. As a gathering place for learning communities, informal learning spaces are essential for ever-changing contemporary society. They are accessible to all people regardless of age and socio-cultural or economic background. In contrast to formal education settings, informal learning spaces offer less pressure and more welcoming environments for individual pace and growth. Collaborative learning in this environment can support intergenerational as well as peer-to-peer interactions. Informal learning spaces also accommodate diverse learning styles and interests. Incorporating biophilic design into these spaces enhances the societal benefits of informal learning while at the same time providing personal advantages such as improved focus, creativity, attentiveness, and a sense of calmness. This study offers insight into how biophilic concepts can be incorporated in alternative learning spaces to enhance the relationship between humans and nature in learning environments.

In the Indonesian context, as a developing country where a significant amount of the population faces economic and educational limitations, the urgency for accessible learning opportunities is crucial. The government has initiated informal and non-formal learning spaces, such as Pusat Kegiatan Belajar Masyarakat (PKBM) or Community Learning Centre in both urban areas like Jakarta, Bandung, Surabaya, and Yogyakarta, and in remote regions such as Karimun Jawa, Nusa Tenggara Timur, Maluku, and Papua, to provide education and skills development for marginalized communities. PKBM is a vital resource for lifelong learning, focusing on literacy and vocational training [41]. Other informal learning spaces are initiated by individuals and communities, such as *rumah singgah* (transitional home or shelter for street children), creative centres, public libraries, and *taman bacaan* (reading parks). These initiatives collectively address the need to reduce the education gap in Indonesian society. They initiate a welcoming, inclusive environment for cultivating knowledge and skills. In this context, simplicity, affordability, and adaptability principles become key considerations in this biophilic approach to designing informal learning spaces for marginalized communities. Therefore, this paper proposes the design concept and implementation illustrations of informal learning spaces supported by a biophilic approach, with key considerations for simplicity, affordability, and adaptability.

3.2 Developing Biophilic Adaptation Criteria for the Contextual Informal Learning Spaces

At the philosophical level, the biophilic approach arises from recognizing that a sensorily rich world is critical to people's health, productivity, and emotional, intellectual, and spiritual well-being [42]. It is more complex and richer than the mere application of vegetation in buildings [43]. In Indonesia, where the majority of people belong to the Muslim community, this biophilic approach aligns profoundly with the concept of fitrah, which refers to the natural disposition of humans and their relationship with the natural world. From an Islamic perspective, nature continuously fulfills the purpose for which God created it, harmonizing with His design. When immersed in such an environment, humans are reminded of their purpose and return to their fitrah, fostering a sense of tranquility and connection to the Creator. Some verses in the Quran resonate with the concept of a biophilic approach, such as Surah Al-Baqarah (2:164), Surah Ar-Rum (30:30), and Surah Sad (38:27). These verses highlight how engaging with natural spaces can remind humans of their purpose and encourage a return to fitrah, or their natural disposition, with purity, balance, and harmony, which profoundly impacts well-being. In essence, biophilic design enriches more than just physical spaces. It bridges human existence with the greater order

of creation and invites a journey back to one's innate purpose in harmony with the Creator's ultimate design.

At the conceptual level, there is diversity in the formulation of biophilic design strategies by authors or researchers. Some studies focus on the relationship between the biophilic design and user experience [10, 24], the quality of life [5, 30, 44] and wellbeing [23, 36] concepts, while others emphasize the integration of biophilic design with sustainability principles [45]. The widely used 14 patterns of biophilic design proposed by Browning et al. [2, 11, 31] comprehensively emphasize both the physical and psychological aspects of biophilic design (Fig. 4). The 14 patterns are categorized into three main categories, namely (1) Nature in the Space, incorporating direct experience of nature, (2) Natural Analogues, exploring indirect representations of nature, and (3) Nature of the Space, employing spatial configurations that evoke feelings of being in a natural environment [2]. This framework provides a comprehensive starting point for this study, with contextual aspects incorporated to enrich the discussions.

Nature in the Space	1. Visual connection with nature 2. Non-visual connection with nature 3. Non-rhythmic sensory stimuli 4. Thermal & airflow variability 5. Presence of water 6. Dynamic and diffuse light 7. Connection with natural systems
Natural Analogues	8. Biomorphic forms and patterns 9. Material connection with nature 10. Complexity and order
Nature of the Space	11. Prospect 12. Refuge 13. Mystery 14. Risk/Peril

Figure 4. Patterns of biophilic design adapted from Browning et al. [2]

An interesting study investigated the correlation between the learning styles of architectural students and their attraction toward biophilic learning spaces [31]. The results indicate a significant connection between students' learning styles and their preferred biophilic patterns. It shows that different learning styles must be accommodated in informal learning environments where more diverse people participate in individual or group learning in an inclusive setting. Neil Fleming's VARK model categorizes learning styles into four main modalities: Visual, Aural, Read/Write, and Kinesthetic. Fleming has recently emphasized recognizing multimodal learners who exhibit strengths across multiple modalities [46].

Compared to formal education settings typically characterized by structured environments such as classrooms and lecture halls, informal learning spaces encourage a more flexible and adaptable environment [47]. Different learning styles may be incorporated in informal learning environments, such as group discussion spaces, individual corners, reading nooks, mini theaters, and exploration spaces. It could also take the form of spaces that can be flexibly adapted to

accommodate different learning at different times of the day. Related to biophilic design, visual learners, for example, might need the incorporation of visual aids such as plants and water features to enhance the learning experience. On the other hand, auditory learners prefer a calming or tranquil environment to enhance their engagement during discussions or while listening to a podcast. A flexible, open area where learners can engage in hands-on activities might suit kinesthetic learners.

Furthermore, incorporating the Indonesian regional context in biophilic design leads to specific adaptations derived from cultural values, local traditions, and environmental conditions across the country's diverse regions. For instance, in the island communities of Kepulauan Maluku and Kepulauan Riau, biophilic implementations might consider coastal winds and the surrounding sea, reflecting the environment's vital role in the communities' livelihoods and daily lives. On the other hand, biophilic design in the heartland of Java might incorporate mountain-inspired elements and locally sourced wood or bamboo. One school concept in Indonesia, namely Sekolah Alam or "Nature School," is well-known for its attempts to integrate biophilic principles into their campuses, reflecting their appreciation for nature and enhancing environmental awareness. Biophilic design can incorporate local materials, traditions, and craftsmanship, integrating its principles with cultural values that emphasize respect for nature. Adaptations to local natural and cultural contexts significantly enrich the foundational principles of biophilic design, fostering a deeper connection between individuals and their environments.

In the context of Indonesian education, poverty is the main reason for dropping out of school compared to having a disability [7, 48]. Fortunately, informal learning has evolved uniquely across regions to fill this gap, influenced by cultural and environmental diversity. Taman Bacaan Pelangi in eastern Indonesia provides children with access to books and literacy activities. They encourage self-directed learning despite many limitations in resources. Kampung Dongeng in Ciputat revives oral traditions through storytelling to teach moral and social lessons, fostering community involvement. These examples demonstrate how informal learning spaces in Indonesia address educational gaps while respecting cultural heritage and environmental contexts.

Given the Indonesian context of informal learning spaces for marginalized communities [41], such as Pusat Kegiatan Belajar Masyarakat (PKBM), Kampung Dongeng, Taman Bacaan Pelangi, and other cases of informal learning settings, this paper emphasizes the importance of adaptability, affordability, and simplicity as key considerations for implementing biophilic design in these environments. These three factors are essential in the design for practical and economic reasons. Criteria should ensure the design is easily adaptable for different purposes, cost-effective, and simple to implement. Adaptability refers to the ability of spaces to be reconfigured to meet various learning needs and local conditions. Affordability entails using cost-effective materials and construction techniques without sacrificing quality or user experience. Simplicity prioritizes straightforward, functional design elements that are easy to maintain and promote a calming learning environment.

After breaking down each component in the above descriptions, the final phase of this process is to synthesize the patterns of biophilic design, the consideration of different learning styles, and the need for a simple, adaptable, affordable design for the Indonesian society context. As a result, six key criteria have been identified: (1) Adaptable, simple spatial layout, (2) Natural sensory-stimulating elements, (3) Affordable & low-maintenance elements of nature, (4) Cost-effective materials with calming natural colors and textures, (5) Seamless connection between indoor, outdoor, and transitional spaces, (6) Adjustable natural and artificial lighting and airflow.

Figure 5 illustrates the criteria synthesized from biophilic patterns, learning styles, and adaptability - affordability - simplicity derived from the contextual considerations. This Venn diagram represents a synthesis of the concepts discussed, highlighting their intersections and distinctions derived from our analysis.

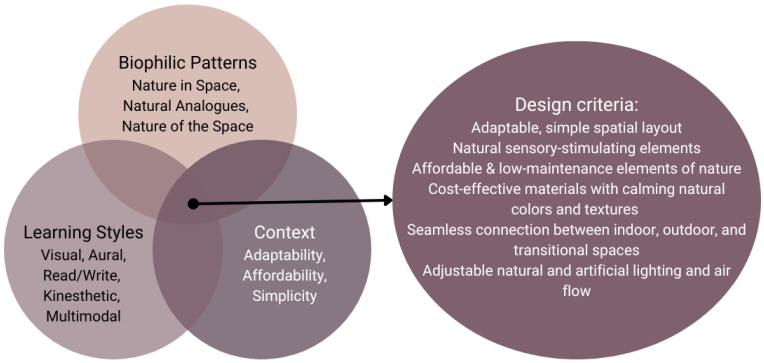

Figure 5. Visual model of conceptual synthesis between biophilic patterns, learning styles, and contextual considerations.

3.3 Illustrating the Implementation of Design Criteria in Informal Learning Spaces

To demonstrate how six design criteria applied in an informal learning setting, this section provides visual representations of the implementations of design criteria in an informal learning space. Fig. 6 is an illustration of how the criteria can be fulfilled in an outdoor space through simple and adaptable biophilic strategies. The depicted design showcases criteria from Fig. 5, including natural lighting and air flow, connection between spaces, cost-effective materials, and affordable, low-maintenance natural elements.

Figure 6. An example of implementing design criteria in a transitional space. Adapted from Maski Isnaini Azizah's final project report [49].

Fig. 7 is an illustration of how the criteria can be fulfilled in a transitional space between outdoor and indoor spaces. The design meets the criteria by incorporating affordable, low-maintenance natural elements, multi-use transitional spaces, natural sensory-stimulating features, and natural patterns to reduce boredom and fatigue.

Figure 7. An example of implementing design criteria in an outdoor environment. Adapted from Maski Isnaini Azizah's final project report [49].

Fig. 8 below is an illustration of how an indoor space of an informal learning space was designed with affordable and adaptable biophilic strategies. It illustrates a design that fulfills the criteria of an adaptable, informal spatial layout with simple furniture, spaces that support both collaborative and solitary learning, seamless connections between indoor and outdoor areas, and adjustable natural and artificial lighting for enhanced comfort.

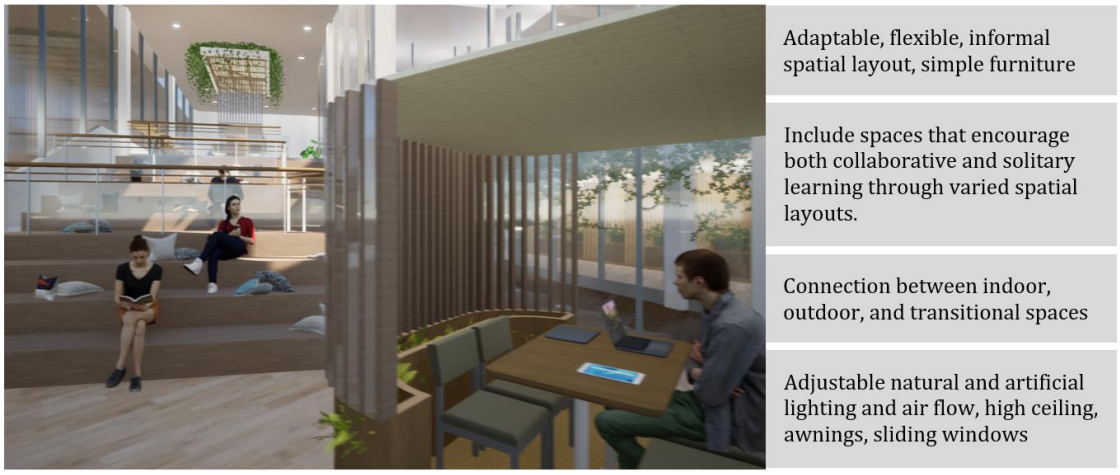

Figure 8. An example of implementing design criteria in an indoor environment. Adapted from Maski Isnaini Azizah's final project report [49].

These examples demonstrate the design criteria discussed, showcasing how these principles can be effectively implemented in informal learning spaces. As illustrated, thoughtful implementation of these principles can lead to spaces that are aesthetically pleasing, functional, and conducive to learning.

4. Conclusion

Integrating biophilic design principles into informal learning spaces offers a compelling opportunity to enhance educational experiences in Indonesia. By considering adaptability, affordability, and simplicity alongside natural elements that promote well-being, we can create environments that support diverse learning styles and foster engagement. This synthesis of design criteria not only supports learners' physical and psychological needs but also encourages a deeper connection with the natural world.

This study acknowledges several limitations that may impact the generalizability of its findings. The focus on a specific context—informal learning spaces in marginalized communities in Indonesia—limits the applicability of the results to other cultural or geographical settings. The qualitative nature of the research may lead to subjective interpretations of data, which can vary based on individual perspectives and experiences.

Future research based on the limitations of this study can be conducted by incorporating a broader range of non-formal learning environments, such as youth camps, professional workshops, and language courses, that are also familiar in the Indonesian context. A mixed-methods approach could also provide a comprehensive understanding of the effectiveness of biophilic design across various settings. Investigating stakeholders' perspectives—such as educators, learners, and community members—would also enhance the understanding of how design elements are perceived and utilized in fostering an effective learning atmosphere.

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