

Multisensory School Design and Learning Motivation: Amplifying Coastal Children's Voices in Batam Island Primary School

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Abstract

School grounds shape children's learning experiences through functional and sensory stimulation. However, in Batam Island, school grounds are often limited in design, with a stronger emphasis on practicality rather than multi-sensory stimulation. This research investigated how multi-sensory school design fosters intrinsic learning motivation among primary school children, focusing on coastal contexts such as Batam Island, Indonesia. Using a mixed-methods approach, this research comprised a systematic literature review with questionnaires administered to purposively selected students. The questionnaire consisted of two sections, with the first section using a Likert scale and the second section investigating through descriptive statistical techniques. Findings revealed that children, whose lives are closely intertwined with coastal nature, value clean environments, nature-inspired and soft color palettes, age-appropriate furniture and seating arrangements, subtle plant-based scents, smooth tactile surfaces, restorative soundscapes, and natural outdoor play areas. These environmental elements influence psychological, cognitive, and social dimensions that sustain intrinsic learning motivation. By amplifying coastal children's voices, this research advocates the value of participatory approaches to school design in distinctive geographic and socio-cultural milieu. Ultimately, multi-sensory school design offers a pathway to advancing SDG 4 (Quality Education), which calls for inclusive, equitable, and lifelong learning opportunities for all.

1.0 INTRODUCTION

Achieving Sustainable Development Goal 4 (SDG 4) on inclusive and equitable quality education, remains challenging in Indonesia due to persistent inequalities in access and infrastructure. As an archipelagic nation, logistical barriers in Indonesia exacerbate an urban-rural divide, leaving island communities underdeveloped and contributing to low international academic performance rankings (Jatayu et al., 2024; OECD, 2023). These disparities are evident in Batam, a rapidly growing coastal city in Indonesia's Riau Islands Province, where persistent shortages of quality educational facilities and resources affect both the mainland (Batam Island) and its surrounding hinterland areas. Recent data recorded approximately 3,000 student dropouts, more than 1,000 of which occurred at the primary level (Kemendikdasmen, 2024). Given the critical importance of early childhood development, these figures highlight the urgent need to target the root causes of dropout rates particularly from the primary level onward in this island community.

Academic dropout is a learner's inability to sustain formal education beyond the compulsory schooling age, whether intentional or unintentional. This phenomenon is typically driven by a complex interplay of individual, familial, school, and socio-economic factors, with low academic achievement, disengagement, and diminished motivation as key predictors (Cimene et al., 2023; Nguyen et al., 2022). Within self-determination theory, which emphasizes psychological needs, Nguyen et al. (2022) highlighted that students who perceive a lack of autonomy in selecting and regulating their learning, combined with a low intrinsic motivation, are more likely to withdraw from school. Thus, the likelihood of premature school withdrawal may increase notably when young learners feel they have limited control over their educational experiences and derive little satisfaction from the learning process.

As one of the most crucial early indicators of potential student dropout, specifically within formal education systems, a decline in learning motivation often manifests as a significant decrease in students' internal drive to attend school, reflecting a lack of the psychological engagement necessary for active participation in structured learning environments (Lonang et al., 2022). While the interplay of internal and external factors can contribute to this erosion of motivation and attention, the learning environment plays a particularly pivotal role in shaping these dynamics (Mustapa et al., 2024). A well-considered and purposefully designed learning environment contributes to students' overall health and well-being, their capacity for sustained attention, and their engagement in the learning process. Therefore, creating an optimized and stimulating learning environment is essential to enhance educational outcomes and enable students to reach their full developmental potential.

Prior studies have explored the application of multisensory-based learning models within primary school settings across diverse nations, including Italy, Portugal, and Indonesia (Cuturi et al., 2022; Ferreira & Vasconcelos, 2020; Junilasari et al., 2017). These studies have demonstrated how integrating sensory stimuli, including auditory, visual, tactile, olfactory, and gustatory, within the learning process can significantly enhance pupils' motivation, attention span, concentration levels, and overall learning quality. By engaging multiple sensory modalities simultaneously, young learners can interact and engage more deeply with instructional content, leading to stronger cognitive engagement and longer lasting understanding. In addition, this approach stimulates children's innate curiosity and makes learning more immersive and meaningful by aligning the natural ways children perceive and process information through their senses.

Despite these promising findings, research on multi-sensory environments in education has focused predominantly on instructional models in specific subjects, such as languages, mathematics, and sciences, and has been mainly limited to land-based areas (Cuturi et al., 2022; Ferreira & Vasconcelos, 2020; Junilasari et al., 2017). Both the application of multi-sensory principles in primary school design for enhancing learning motivation and the active involvement of children in this process have received limited attention (Cuentas & Bernedo-Moreira, 2024). Learning motivation is shaped by multiple factors, including demographic, psychological, cognitive, social, and environmental conditions (Ishida & Sekiyama, 2024), and may thus vary across geographical contexts, such as coastal areas with distinct geographical and sociocultural circumstances. Research in these contexts has predominantly examined community participation in enhancing coastal children's learning motivation (Devi et al., 2020), overlooking the potential influence of other factors, especially the school-built environment.

To address these gaps, this research investigated how multisensory-based interventions in primary school design can enhance students' learning motivation in coastal regions, using Batam Island, Indonesia, as a case study. In doing so, this research examined the integration of multi-sensory principles into the design of learning environments and underscored the importance of children's active participation as primary users in shaping those environments. By listening to the voices of coastal children, the research generated empirical evidence that illuminates the specific mechanisms through which multi-sensory design can foster intrinsic motivation. These findings can contribute to a nuanced understanding of how educational spaces can be tailored to geographically and socio-culturally distinctive contexts, advancing the discourse on participatory, child-centered approaches in school design.

2.0 LITERATURE REVIEW

2.1 Multisensory Design in Educational Settings

Mane and Hullur (2024) defined "sensory", within the context of human perception and physiological mechanisms, as the fundamental human faculties of touch, taste, smell, sight, and hearing through which individuals perceive and interpret the world. These senses respond to external stimuli and transmit essential information to the brain for cognitive processing, underscoring their indispensable role in environmental understanding. Environments enriched with diverse sensory inputs can evoke emotions, strengthen memory retention, and deepen spatial comprehension (Bakir et al., 2020). Incorporating visual, auditory, olfactory, kinesthetic (movement), and tactile elements into architectural design has been increasingly acknowledged for its capacity to cultivate immersive and meaningful spatial experiences (Spence, 2020). However, individuals may differ in their sensitivity to various sensory domains, resulting in distinct perceptual experiences. This condition can be influenced by internal factors such as gender, age, and spatial perception ability (Chen et al., 2022). Accordingly, identifying users' specific perceptions and preferences toward sensory stimuli is crucial when designing effective multi-sensory environments.

Moreover, scholars have discussed the principles of multi-sensory learning, which engages multiple senses to enhance children's comprehension of educational material (Cuturi et al., 2022; Ferreira & Vasconcelos, 2020; Junilasari et al., 2017; Suryaratri et al., 2019). As Suryaratri et al. (2019) suggested, using multi-sensory approaches in education provides children, regardless of their learning abilities, with more equitable opportunities to learn, and simultaneously, more inclusive educational spaces. Children with visual or auditory processing difficulties may struggle to understand information presented solely through reading or listening. They rightly added that combining digital and physical elements within a learning environment, often a blended multi-sensory approach, is considered effective in promoting cognitive development and long-term memory formation. By offering interactive and immersive learning experiences, this approach potentially enriches the quality of education for young learners.

While researchers have examined multi-sensory learning environments through the use of pedagogical tools in educational settings to enhance comprehension, engagement, and memory retention, Barrett et al. (2015) suggested sensory stimulation levels as one of the key dimensions of the school's built environment that can significantly influence pupils' academic performance and behavior. Furthermore, Kalinkina et al. (2023) emphasized the potential of colors and forms as architectural elements that positively shape young learners' experiences. Similarly, Mane and Hullur (2024) pointed out the contribution of multi-sensory design to spatial awareness and navigational skills. Coordinated sensory cues, such as tactile textures or spatially informative sounds, can help children better comprehend spatial layouts and develop orientation abilities. These multi-sensory strategies can enhance educational value and foster environments that are comfortable, safe, and responsive to children's developmental needs. Nevertheless, the specific impact of multisensory-based school design on primary school children's learning motivation remains unclear. Advancing research in this area is crucial, as applying well-founded multi-sensory design principles can meaningfully enhance educational outcomes, promote holistic child development, and ensure that primary school environments are optimally conducive to learning.

2.2 Factors Influencing Students' Learning Motivation

Student learning motivation is a multifaceted phenomenon influenced by various interconnected factors. As highlighted in Ishida and Sekiyama's (2024) critical literature review, demographic, psychological, cognitive, social, and environmental factors significantly affect learners' motivation. Demographic influences include age, gender, socio-economic status, and cultural background. However, their synthesis indicated that much of the existing research has focused on university students predominantly in China and the United States, overlooking younger pupils and more culturally diverse populations. Psychological determinants encompass emotions, attitudes, self-perceptions, and goal orientations, whilst cognitive factors relate to learning abilities and perceived self-efficacy.

Ishida and Sekiyama (2024) further explained that social and environmental factors encompass the learning environment, such as the influence of peers, teachers, and family, and broader social influences. Shilova et al. (2019) revealed that practical pedagogical approaches, such as gamified learning, hands-on activities, and curricula aligned with learners' cognitive capacities, can notably enhance engagement. Equally, teachers who demonstrate enthusiasm and cultivate dynamic, emotionally engaging classrooms, along with supportive parental involvement through moral and material support, contribute significantly to motivation (Shilova et al., 2019; Suryaratri et al., 2019). In addition, the social dimensions of the classroom, such as positive peer relationships and opportunities for collaborative learning, foster a sense of belonging and encourage active participation (Suryarini, 2021). Community involvement in children's educational experiences can further enhance motivation, with distinctive impacts observed in coastal contexts (Devi et al., 2020). However, despite these insights, limited research has examined how these factors interact with physical school design, especially within multi-sensory environments, to influence motivation in primary education.

3.0 METHODS

This research employed a mixed-methods approach to facilitate a comprehensive exploration of the research problem by integrating both qualitative and quantitative paradigms (Creswell & Creswell, 2022). This methodological strategy enabled the triangulation of insights, combining descriptive data from literature reviews with empirical data collected through questionnaires. Specifically, the quantitative component consisted of questionnaire-based Likert-scale responses and descriptive statistics, whereas the qualitative component involved interpretive analysis of preference-based responses supported by visual stimuli and theoretical synthesis from the literature.

Data collection involved two key stages. Firstly, a systematic literature review was conducted to inform the development of the questionnaire instrument. Academic databases including Scopus, Web of Science, and Google Scholar were searched using predefined keywords, such as "multi-sensory design", "multi-sensory learning", "learning environment", "primary school", "coastal areas", and "learning motivation". Inclusion criteria focused on peer-reviewed journal articles published in English and Bahasa Indonesia. The reviewed literature was synthesized to identify the possible implementation of the five core principles of multi-sensory design, including sight, hearing, smell, movement, and touch, in educational settings and factors influencing students' learning motivation, which subsequently guided the structure of the questionnaire and data analysis. Secondly, the questionnaires were administered to purposively selected primary school students on Batam Island, Indonesia, to investigate their perceptions of existing multi-sensory conditions in the learning environment and their preferences for multi-sensory learning environments that may enhance intrinsic learning motivation. Participant eligibility required current enrolment in the target school on Batam Island, Indonesia, for their present implementation of multi-sensory initiatives (Figure 2-3). This condition ensured that participants had direct experience with certain multi-sensory features, enabling them to provide informed evaluations of existing conditions while envisioning potential enhancements for an ideal learning environment. An additional criterion was an age range of 7–11 years (Grade 1-6), aligning with Piaget's concrete operational stage of cognitive development, which is characterized by the development of logical reasoning and the ability to mentally simulate everyday scenarios (Malik & Marwaha, 2023). Accordingly, a total of 210 students participated in this research.

Prior to data collection, the questionnaire underwent expert review to ensure content clarity, age appropriateness, and alignment with the study objectives. Minor wording adjustments were made based on this review to enhance comprehensibility for elementary school students. The questionnaire, titled *My Dream School*, was structured into two sections. Part A comprised eight statements, allowing participants to assess their existing learning environment, and provided a baseline for comparison with an envisioned multi-sensory setting. Part B included seven preference-based questions designed to capture students' expectations and aspirations for an ideal multi-sensory learning environment. To support comprehension and stimulate the imagination among children aged 7–11, Part B incorporated visual illustrations depicting different sensory scenarios. Students selected their preferred options based on these visual cues. The specific statement topics related to learning motivation in both sections were derived from the five core principles of multi-sensory design (sight, hearing, smell, movement, and touch); Part A focuses on the existing multi-sensory stimuli, and Part B explores potential improvements. The questionnaire was administered in a supervised classroom setting to ensure consistent understanding among participants. Researchers and teachers provided brief verbal explanations of each section for students in Grades 3-6, while younger students were guided through the questionnaire on a question-by-question basis as suggested by the teachers. Students were allowed to ask clarification questions before responding, and they completed the questionnaire individually to minimize peer influence.

Subsequently, the responses using the Likert scale in Part A were analyzed to evaluate the level of agreement or disagreement with each statement. Each response option was assigned a numerical value: Strongly Disagree (SD) = 1, Disagree (D) = 2, Neutral (NA) = 3, Agree (A) = 4, and Strongly Agree (SA) = 5. The mean score was calculated and interpreted for each item using the following categorization as shown in Table 1. Responses from Part B were analyzed using descriptive statistical techniques, presented through charts and expressed as percentages to identify dominant response patterns. Narrative interpretation was employed to relate these patterns to multi-sensory design principles and their potential impact on coastal children's learning motivation. This combined approach provided a quantitative overview and a qualitative understanding of the data key characteristics (Creswell & Creswell, 2022).

Table 1. Category of influence.

Mean Score Range	Category
1.00 – 1.79	Low Influence
1.80 – 2.59	Moderately Low Influence
2.60 – 3.39	Neutral Influence
3.40 – 4.19	Moderately High Influence
4.20 – 5.00	High Influence

4.0 RESULTS AND DISCUSSION

4.1 Part A: Existing Multi-Sensory Conditions in the Learning Environment

Overall, Figure 1 illustrates that the current learning environment (see Figures 2 and 3) moderately influenced students’ intrinsic motivation to learn, with the three highest-rated principles being visual (V), kinesthetic (K), and olfactory (O).

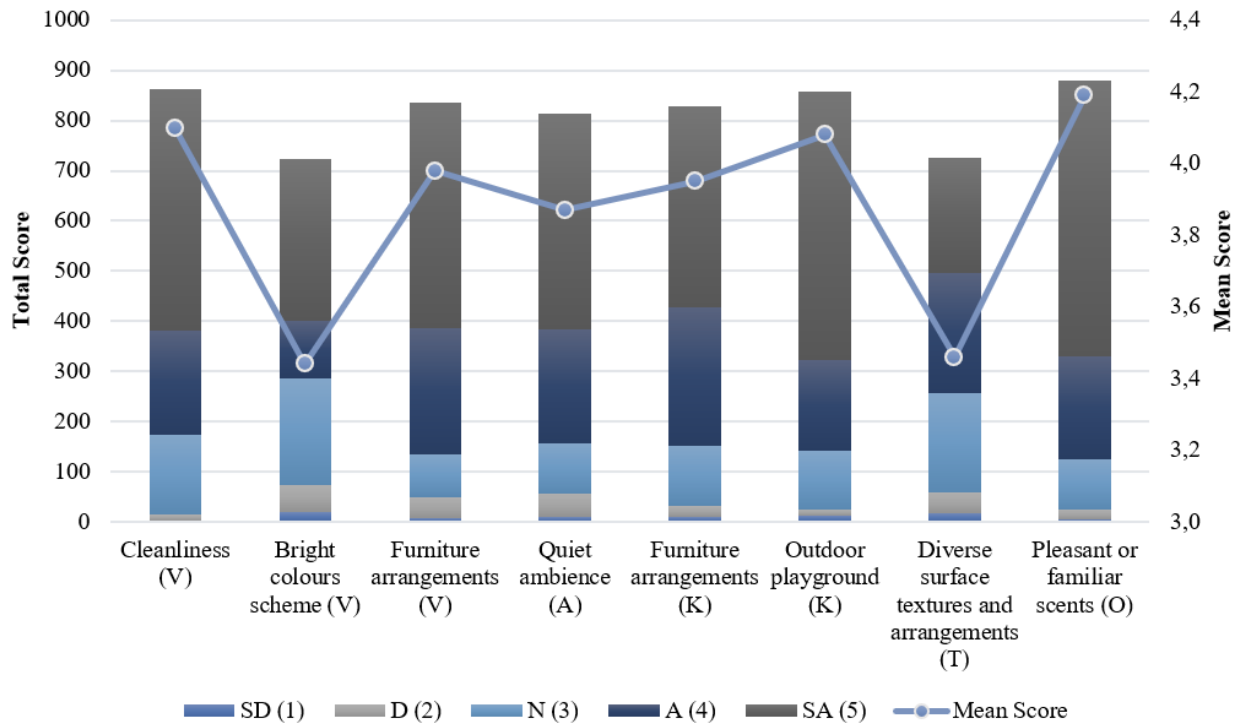


Figure 1. Students’ perceptions of existing multi-sensory conditions in the learning environment.



Figure 2. Existing classroom conditions in the selected primary school on Batam Island, illustrating the typical bright color scheme, furniture arrangement, and spatial layout, as well as wall textures and patterns.



Figure 3. Existing outdoor space conditions in the selected primary school on Batam Island, illustrating the typical bright color scheme, outdoor garden, and playground.

Most students perceived pleasant or familiar scents as the most influential factor in enhancing their motivation to learn, achieving the highest mean score of 4.19. This was closely followed by the school's cleanliness and the availability of an outdoor playground (see Figure 3). Such olfactory stimuli appeared to create a comfortable and focused learning atmosphere that can sustain students' interest in academic activities. A clean environment provided children with good visual stimuli that improved their learning concentration and motivation. This is aligned with the study by Uleanya (2020), which examined the impact of hygienic school environments on students' academic performance. Furthermore, the playground's role in enabling kinesthetic engagement through active play was also strongly associated with higher student enthusiasm for learning. Complying with Zarina Akbar and Awalludin's (2020) suggestion, these opportunities for movement encourage motoric stimulation that supports children's physical, cognitive, and socio-emotional development, enabling them to approach classroom learning with greater confidence and self-esteem.

While the average scores for other environmental conditions, such as a quiet ambience and the arrangement of classroom furniture, were slightly below 4, both the recent use of bright colors, such as red, yellow, blue, and green, and the incorporation of varied surface textures and patterns within the school (see Figures 2 and 3) received mean scores of approximately 3.4, highlighting their minimal impact on students' learning motivation compared to other stimuli. Participants reported being more motivated when the classroom maintained a low noise level because this supported their ability to concentrate. Additionally, appropriately positioned learning tools, such as whiteboards placed at a height suitable for children, and the current seating arrangement in traditional rows (see Figure 2), were perceived as facilitating the learning process. This configuration enables the students to maintain clear lines of sight and easily move through the classroom, supporting engagement and accessibility.

This pattern implies that, whilst visual, kinesthetic, tactile, and olfactory stimuli were present and valued in the current environment, their design and integration could be more intentionally leveraged to maximize their impact on learning motivation. Similarly, although auditory stimuli in the existing condition were limited, as primarily reflected in the classroom's quiet ambience, they moderately affected the students' motivation.

4.2 Part B: Coastal Children's Preferences Toward Multi-Sensory Design in Learning Environments

The bar charts below (Figure 4-8) illustrate the participants' preferences regarding multi-sensory design that can enhance intrinsic learning motivation. The findings exhibited clear opportunities for targeted design interventions that could substantially improve the school environment. Given that the school's cleanliness was already considered satisfactory, with a mean score of above 4, the visual stimuli questions focused on preferred color schemes and the arrangement of furniture, especially the design and configuration of seating. Moreover, certain sounds, scents, textures, and supporting facilities for physical activities emerged as the most influential stimuli, as they were perceived to directly enhance enthusiasm for learning among primary school students in this island community.

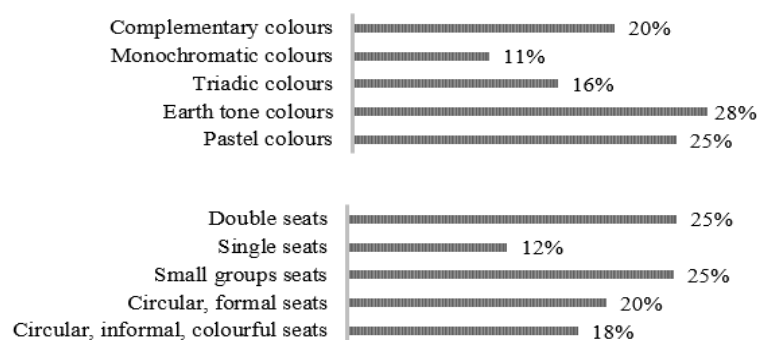


Figure 4. Preferred Visual Stimuli.

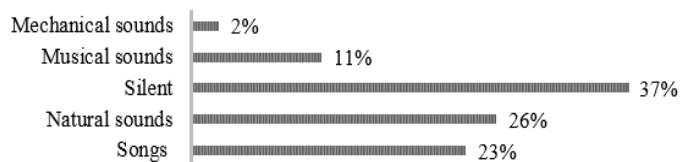


Figure 5. Preferred Auditory Stimuli.



Figure 6. Preferred Olfactory Stimuli.

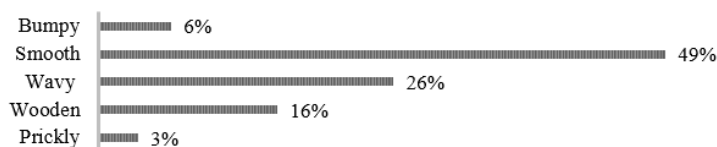


Figure 7. Preferred Tactile Stimuli.

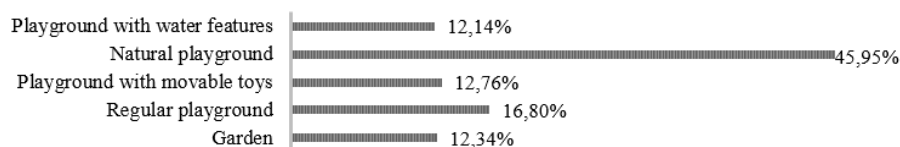


Figure 8. Preferred Kinesthetic Stimuli.

5.0 DISCUSSIONS

5.1 Visual Stimuli: Cleanliness, Colors, and Classroom Arrangement

This research highlights the critical role of a clean school environment in enhancing the learning motivation of primary school students. For younger children especially, regardless of the geographical context, clutter and untidy surroundings often trigger overstimulation, which increases stress (Schmeer & Yoon, 2016), hence diminishing their capacity for sustained concentration on learning tasks. Conversely, beyond aesthetic appeal, a well-maintained and hygienic space reduces sensory distractions and often creates a more legible, orderly, and predictable setting. Such environments can foster a sense of security, emotional comfort, and focus (Barrett et al., 2015; Matthews & Lippman, 2020), which are foundational for motivation and readiness to learn. These findings confirm that the motivational benefits of cleanliness are consistent across geographical contexts, underscoring its universal importance in supporting young children's motivation.

While previous studies have highlighted the positive stimulating effects of vibrant colors on children (Aguspriyanti et al., 2024; Barrett et al., 2015), the results indicated that the use of these colors in school design can only moderately influence motivation. As shown in Figure 4, the findings further revealed that students in the observed primary school in Batam Island were more strongly drawn to softer, nature-inspired schemes, such as earth-tones and pastel colors, with 28% and 25% of responses, respectively. These palettes are likely to reflect the coastal environment of sand, sea, and sky and so evoke a sense of familiarity that nurtures psychological comfort and well-being, ultimately strengthening children's intrinsic motivation to learn. By evoking tranquility and reducing stress, earth tones and pastels also help create a calming atmosphere (Singh et al., 2024), sustaining interest and engagement in learning activities. This finding raises critical questions about the generalizability of color psychology in educational settings, which has traditionally been dominated by research conducted in land-based or Western contexts. The data here point toward a culturally and environmentally embedded dimension of children's environmental preferences, in line with theories of environmental psychology that emphasize place attachment and sensory familiarity.

Classroom spatial configuration, such as the positioning of learning tools and seating, should also be thoughtfully designed to align with children's needs and conditions. The results indicated how the accessibility of learning tools matters greatly. Tools, such as white boards, placed at children's eye level or within easy reach promote independence and self-directed exploration, reinforcing their sense of agency. While traditional row seating, where each student has their own desk and faces the front, was still moderately valued, the highest preferences were for double seating (25%) and small-group arrangements (25%) (see Figure 4), indicating a stronger inclination toward more interactive layouts. Such arrangements shape how children see and engage with one another, fostering both social cohesion and a sense of belonging. This finding aligns with Ishida and Sekiyama (2024), who underscored the motivational and socio-emotional benefits of peer interaction. Nevertheless, it is essential to simultaneously account for cognitive considerations, as students' grade level significantly influences their need for focus and concentration. For instance, younger children often thrive in group-based learning due to their need for social bonding (Over, 2016), whereas older children may require more focused environments that minimize distraction.

5.2 Auditory Stimuli: Quietness and Natural Sounds

As presented in Figure 5, a calm and quiet classroom environment emerged as the most favored condition, with over 30% of responses in part B, indicating that reduced noise significantly enhanced enthusiasm for learning. However, a totally noise-free environment may not always be preferable and beneficial for children's learning process (Matthews & Lippman, 2020). Interestingly, the findings showed that 26% of participants preferred natural sounds, such as birdsongs, trickling water, and ocean waves, making it the second most favored option. Such auditory stimuli are known to have beneficial effects on students' emotions, cognition, and attentional restoration (Pellegatti et al., 2023; Ratcliffe, 2021), thus potentially nurturing intrinsic motivation. This preference also strongly reflects the coastal identity of Batam children, whose daily lives are shaped by proximity to the sea and exposure to natural soundscapes. Hence, this research suggests that striking a balance between quiet conditions and subtle natural soundscapes may not only optimize auditory stimulation for learning but may also resonate with the lived experiences of children in coastal environments, helping them feel both engaged and at ease within classroom settings.

5.3 Olfactory Stimuli: Fragrance and Plant-based Scents

Pleasant or familiar aromas, especially artificial fragrances (37%) and natural plant-based scents (35%), were identified as important motivational factors in this research (see Figure 6). Artificial fragrances, which often replicate distinctive smells, appeared to hold a particular appeal for some children in Batam Island, potentially making such scents more personally engaging and thus more effective in stimulating learning enthusiasm. At the same time, the fresh and sweet aromas of plants (35%) were also perceived as highly motivating, adding the beneficial effects of nature-based odors on cognitive performance, reducing stress, and enhancing mood (Tong et al., 2025). This research underlines how olfactory cues, which are often overlooked in classroom design, can meaningfully shape emotional well-being and motivation. From a practical standpoint, schools could consider integrating safe and nonintrusive scents, either through natural vegetation or subtle artificial fragrances, to create more engaging and psychologically supportive classrooms. Nonetheless, caution is required, as excessive or inappropriate use of scents may trigger allergies, sensitivities, or sensory overload in some children.

5.4 Tactile Stimuli: Comfort and Smooth Surfaces

Figure 7 illustrates that whilst diverse surface textures and arrangements were found to have a relatively modest influence on young learners' motivation, nearly half of the participants preferred smooth surfaces. This emphasizes the central role of tactile comfort in creating supportive learning environments. Such pleasant tactile experiences have been shown to assist in emotional regulation and relaxation among adults (Kim & Park, 2025), and similar mechanisms may extend to children. For primary school pupils in coastal settings, the preference for smooth textures may reflect a desire for safety and stability, in contrast to the rough and irregular surfaces commonly encountered in natural environments such as sand or rocky shores. Rough textures, while natural, may create discomfort, distract attention, or even evoke restlessness, particularly among younger learners, who tend to be more sensitive to sensory input. The incorporation of smooth and reassuring tactile elements into classrooms may help students feel reassured and focused, which in turn, supports children's intrinsic motivation to learn.

5.5 Kinesthetic Stimuli: Classroom Arrangement and Natural Outdoor Play

An effective classroom arrangement is not merely a matter of aesthetics or positive visual stimuli but plays a direct role in sustaining children's intrinsic motivation by facilitating ease of movement and interaction. A well-organized spatial layout enhances engagement and accessibility, enabling pupils to concentrate more effectively on learning activities. Yet, many conventional school designs continue to rely on rigid indoor layouts that prioritize order and functionality over flexibility and children's developmental needs. From a developmental psychology perspective, this can give rise to some issues, as children learn through active exploration of their environments. A static and restrictive layout, therefore, limits kinesthetic learning opportunities, ultimately undermining motivation.

The findings of this study provide further evidence for embodied cognition theories, which argue that physical movement and sensory engagement are integral to cognitive processes. The strong preference for outdoor play in natural playgrounds (see Figure 8), particularly those featuring hill-shaped landscapes and diverse natural elements, underscores the critical role of kinesthetic experiences in maintaining enthusiasm for learning. These environments not only stimulate movement, creativity, and sensory exploration but also nurture the social dimension of motivation by fostering collaboration and peer connection. For children in island settings, whose daily lives are closely tied to coastal nature, nature-based play is not simply recreational but constitutes a vital motivational resource.

Ultimately, aligning with Aguspriyanti et al.'s (2025) findings, the strong affinity of island children for coastal nature can be reflected in their overall preferences for nature-based stimuli, showing clearly how environmental familiarity can be mobilized as a motivational resource based on children's own perceptions and lived experiences. Empirical evidence from this research underlines the way multi-sensory experiences intersect with psychological, cognitive, and social dimensions: psychologically by fostering comfort and emotional well-being, cognitively by sustaining attention and focus, and socially by promoting peer interaction, collaboration, and a sense of belonging. Therefore, this research extends Ishida and Sekiyama's (2024) critical review, advancing the argument that motivation in learning cannot be reduced to individual traits alone but must be understood as dynamically embedded in environmental design.

6.0 CONCLUSIONS

This research highlights the pivotal role of multi-sensory school design in fostering intrinsic learning motivation among primary school children in Batam Island, Indonesia. Aligning with the broader literature, the findings confirm that the quality of physical environments significantly shapes children's psychological outcomes. By amplifying children's voices, the present research shows how both indoor and outdoor school grounds influence learning experiences through functional and sensory stimulation. Nature-inspired classrooms and outdoor environments not only meet developmental needs but also provide positive stimuli that balance familiarity with curiosity, particularly for coastal children. Design strategies include a clean environment with earth-tone or pastel palettes that evoke calmness, age-appropriate furniture and seating arrangements that balance collaboration with focus while offering convenient movement, and tactile comfort through safe and smooth materials. Auditory enrichment, such as balancing quietness and recordings of natural sounds or water features, and olfactory elements like pleasant aromas from natural plants or artificial air fresheners can further enhance sensory well-being. Beyond classrooms, outdoor play areas incorporating natural features such as boulders, sand, logs, plants, and hill-shaped landforms encourage kinesthetic engagement, creativity, and social interaction. Collectively, these strategies transform schools into motivational and inspiring landscapes that support academic learning while nurturing social connection, emotional resilience, and holistic well-being. The research also underscores the importance of advocacy in design: listening to children lived experiences generates actionable insights for creating school environments that are inclusive, culturally rooted, and ecologically responsive. Positioning multi-sensory design as a child-centered strategy enables island communities to cultivate more equitable and engaging learning spaces.

Although this research provides an initial empirical insight into coastal primary students' preferences for multi-sensory learning environments, several limitations should be acknowledged. As the study was conducted in a single primary school in a coastal city, future research should include multiple schools across diverse coastal contexts, such as small islands, to enhance external validity and generalizability. The use of a

questionnaire with only five predefined scenario options per item may have constrained students' responses. Therefore, future studies could incorporate more varied or open-ended scenarios and increase student participation through methods such as student drawings, classroom observations, interviews, and co-design activities to capture more nuanced interpretations of multi-sensory environments. Moreover, a reliance on self-reported preference data reflects immediate subjective responses and does not permit conclusions to be drawn about sustained behavioral change or learning outcomes. To address this limitation, future research might employ experimental or longitudinal designs and include objective outcome measures, such as attention, task persistence, and academic achievement. Finally, examining individual differences, including age, gender, socio-economic background, ethnicity, and sensory sensitivity, would help clarify how multi-sensory preferences and their educational impacts vary across learner subgroups in coastal settings.

To sum up, multi-sensory school design extends beyond aesthetic or functional enhancement. When architectural interventions are guided by children's perspectives as well as by their sensory and developmental needs, schools can reduce barriers to participation, expand access to quality learning, and strengthen social connectedness. Multi-sensory design can serve as both a pedagogical and social investment, ensuring that school environments not only support academic achievement but also empower children as active participants in shaping their own educational journeys. Therefore, it can directly advance the aims of SDG 4 (Quality Education), which emphasizes inclusive, equitable, and lifelong learning opportunities for all.

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