Narrative Review Approach on the Readiness of the Vertical Greenery Adaptation to the Public-School Building in Malaysia

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Abstract. Global climate concerns include deforestation and environmental change. The implementation of the concept of reintroducing nature to the urban school landscape may promote sustainable development and enhance the city's environment quality. The Vertical Greenery System (VGS) is an important aspect in public school building because it offers sustainable urban schooling thebenefits. However, low awareness school amongst government and public, as well as concerning on additional cost of construction and maintenance have become a barrier in adopting the VGS in public-school. Due to lack of studies and analysis on VGS implementation in schools, this paper aims to examine the VGS adaptation strategies towards the readiness of VGS implementation in public school buildings as well as the implications for students' social well-being. This paper focuses on using a narrative review method and deductive thematic analysis to perceive the readiness of VGS adaptation amongst government and public in public school building. The projected outcome will explore the cost-benefits of VGS installation, with considerations of environment, and social well-being towards public-school. Hence, this paper also suggested that VGS can significantly improve the student learning performance, social interaction amongst student's experience and overall built environment of public- school.

Keywords: *Vertical Greenery System (VGS, Public School Building*

1. Introduction

The Vertical Greenery System (VGS), have been created during the last two decades and are gaining popularity in the built environment. A strategy for VGS development with planting in the ground at grade, as well as planter boxes (both at grade and wall mounted) along with horizontal and vertical solar screens over windows, doors, and glazed areas, let alone vertical hydroponic systems. VGS adaptation has been studied in depth in several studies to find the most cost-effective balance with the goal of

determining the most cost-effective methods and their deployment. Even if economic evidence is contradictory, vertical greenery has a good effect on society and the environment [1].

As a result, the vast majority of studies on VGS in urban tropical climate environment have concentrated on specific buildings, such as commercial and residential buildings, with only a few studies on public buildings. Considering public buildings play such an important role in society, they do indeed have a great visual impact, but modernising façade design will also boost the well-being of building users [9]. This paper aims to examine the current state of VGS implementation in public school buildings, as well as the readiness of the system, and perhaps even the implications for students' social well-being.

2. Methodology

Prior to implementing VGS into public school buildings, it was necessary to review relevant literature and discover relationships among elements affecting student health, classroom thermal comfort, as well as students' learning performance. This paper performed a deductive thematic analysis to analyse the data as part of the narrative review process. This method incorporated the usage of keywords such as 'Vertical Green System', 'students' health and well-being', 'uncomfortable classroom temperature conditions' and 'hot humid climatic impact on students' learning performance' to help guide the discussion and analysis. The articles were discovered to be 153 as a result of these efforts. In actuality, merely 62 of the more highly qualified articles had made that through the second stage of the screening process. 10% of the studies explored VGS in school buildings, 33% in residential and commercial buildings, and some other papers discussed VGS deployment in general. This assortment is dominated by VGS in office and commercial buildings. Only a few articles from Malaysia and other countries addressed VGS in school building. The design of the school VGS model was influenced by six key sources (Table 1). It has become possible to advocate benefits of VGS adaptation that are ideal for Malaysian public schools and students' educational and learning situations.

The report begins by outlining the government and public readiness for school building design as it pertains to VGS adoption. Additionally, it has a direct impact on the health and productivity of students, in part because of their exposure to year-round precipitation (and the accompanying heat and humidity). Six adaption options are then suggested: lifecycle costing, cost-benefit analysis, plant selection, a greening campaign to promote VGS's vital responsibilities and benefits, decision support and sustainability policies, and sensitivity analysis. These proposed strategies are thought to be reasonable for the government to fund for building and maintenance, as well as educational programmes, in the interests of long-term education and indeed the prospective school environment.

Table 1. Articles reviews of VGS adaptation strategies towards public schools

Title of article	Source	VGS adaptation strategies in public schools suggested
Evaluating the coolingeffects of greening for improving the outdoorthermal environment at an institutional campus in the summer.	[5]	Decision support tools to analyse greening performance, sustainability policies to promote the construction of green buildings and greening facilities, greening program on campus, on-site measurement program.
Thermal comfort in educational buildings: A review article.	[6]	Awareness and education to both teachers and students of sustainable benefits, explore their preferences in learning and prior determine student comfort level, experimental and simulation studies.
Vertical Greenery Systems and its Effect on Campus: A Meta-Analysis.	[7]	Greening program among students and community, selection of plants, initiating practices for sustainable approaches, installation of mock-up for testing.
Cost-benefit analysis of living wall systems on school building skins in a hot climate.	[8]	Cost-benefit analysis in terms of environmental impact and energy consumptions.

Title of article	Source	VGS adaptation strategies in public schools suggested
Socioeconomic feasibility of green roofs and walls in public buildings: The case study of primary schools in Portugal.	[9]	Life-cycle costing, cost-benefit analysis, allocate initial investment, selecting plants for easy or less maintenance, promotes important role in the well-being, identify the most strategic location, identify underused space, conduct sensitivity analysis.
Design analysis to achieve Green/Eco School building design typology for Malaysia.	[10]	Site planning and design process focusing on details classroom design on green corridor, climatic consideration, green technology application.

3. Impact of the Thermal Discomfort towards Students Schooling

3.1. The Concept of VGS

Vertical Greenery System (VGS) is a green building way of conceptualizing the growing of vegetation on otherwise available façades of buildings from an ontological perspective The most well-known and pioneering vertical greenery system concept may be traced back to the 7th century B.C., when the Hanging Gardens of Babylon were constructed. Green walls had always been decorative or horticultural. Although in this current day, the utilisation of vertical greenery in the form of passive approaches is employed to increase sustainability [11]. Plants on building facades can serve more than only their shade, noise pollution, insulation, and energy demand-reduction functions; they can add an aesthetic boost to the structure's appearance as well [2]. The main advantages of VGS in buildings are environmental and economic in nature, however aesthetic and social-ecological benefits are also presentin the urban built environment.

In a tropical environment, most public schools adopt passive design principles to optimise their building cooling benefits. Therefore, this research aims at offering adaption strategies of VGS for public school design to the government and people in order to promote student health, comfort and well-being.

3.2. VGS in Malaysia

The bulk of VGS are launched in tropical countries in commercial and shopping malls, whether indoor or outdoor. In 2008, the potential of VGS in Malaysia was investigated, and various public areas and commercial buildings began to install it. Malaysia has about 8,000 plant species, approximately 2,500 of which grow without soil and can be probed for vertical greenery plant types. The majority of VGS initiatives in Malaysia were created for aesthetic and environmental grounds, with only few other built for economic reasons [12].

3.3. School-Building in Malaysia

There are studies that show that Malaysian students spend an average of only 27 percent of their daily time awake in school, compared to 8 hours of sleep at home or in the community [14]. Well-being and social interaction can be promoted through education, which can lead to better health, stronger civic engagement, and reduced crime. However, children's cognitive, social, and emotional skills can be hampered by isolation, a poor community setting, inadequate infrastructure, including thermal comfort, and a poor learning environment [15].

Public schools in Malaysia were designed with common linear form of building layout, with basic considerations of physical activity infrastructure for schooling. Also, the Public Work Department (PWD) projects for public schools typically use standard dimensions and identical materials (i.e., concrete construction). As a result of this, the PWD has already constructed school buildings throughout Malaysia that meet new criteria for school design with more passive design elements added, which helps in promoting comfortable schooling activities, and named them accordingly, referring to the Malaysian's guidelines for community facilities and building planning, economic planning unit, Ministry of Education, and the PWD's green rating. Malaysia's Education Blueprint 2013 to 2025 [14] made no mention of a physical infrastructure strategy, or for the construction of schools or public schools. There was however a provision of RM800 million in Malaysia's budget for 2021 declared by the finance

minister in year 2020 to ensure a conducive learning environment by paying for the maintenance and repair costs of public schools [24]. Since the authorities has the chance to implement green design practises like VGS in the building, they should see this as a great opportunity [14].

3.4. Impact on Students' Learning Performance, Health and Safety during Schooling

The quality of school building design impacts student achievement and teacher performance through increasing academic and recreational opportunities for the school community. Working in a noisy environment is not good for young children's development. As a result, integrating VGS into classroom design can improve acoustic effects and reduce noise levels within classrooms [17]. Flowers give aromatic freshness and a learning experience for the students and teachers at VGS. It creates a fragrance in natural spaces [18].

Various research on the impact of greens in schools on health and productivity have discovered this. Previously, it was demonstrated that we do not live in an area free of hazardous particles. Other than CO2, the air we breathe is contaminated, which include with other living creatures viz viruses, pollen, and many others. Indeed, the presence of humans in a room generates CO2, heat, and humidity, as well as filth, dust, and dander [19]. The increased CO2 concentration may lead to headaches, lethargy, heavy-headedness, weariness, and loss of focus in students [25]. However, according to another study, classroom's CO2 levels should be kept below 1,000 ppm (ASHRAE) [34].

Most teachers will create and maintain a conducive learning atmosphere to prevent disruptive behaviour. Study after study has shown that exposing children to nature reduces stress levels, boosts productivity, and enhances emotional well-being [20]. Students in greener schools reported less violent and abusive behaviour, less vulgarities, and less fear. For example, properly built and managed green spaces can reduce crime in residential areas, making communities safer and healthier. A poorly planned and maintained green space, on the other hand, can root and spread crime [21]. This study is warranted considering VGS can reduce bullying and increase social security among students. An indoor, daylit, tree-lined "street" and high levels of internal windows with views onto the street and areas improved social interaction and sense of belonging [16]. Students in the green window view condition performed better on attentional assessments and recovered faster from stressful encounters than their counterparts in the red window view condition [13].

3.5. Impact on Interior Cooling, Shades and Thermal Comfort

Previous studies have demonstrated that employing VGS on the façade is beneficial in improving air circulation, lowering the buildings inside temperature in hotter and humid areas. The adoption of VGS can lead to significant energy savings [5]. VGS has a large capacity to intercept direct solar radiation, leading to significant drops in the external wall and indoor temperature [11]. A previous research literature review of seven studies was conducted-from tropical climates, namely Malaysia, Thailand, Hong Kong, Indonesia, and Singapore, while one research originates from the Middle East. They were all investigated to see how interior cooling and thermal comfort could be linked together. Table 2 shows that all the studies will experience bigger reductions in daylight fluctuation with a larger leaf covering area. Indoor humidity must be addressed along with the overall number of hours spent in the room, as well as the ventilation design.

Table 2. Impact on interior cooling and temperature reduction of vertical greenery system

Location	Authors	Temperature of VGS adaptation in comparison with bare wall
Tehran-Iran	[6]	Warm season: 0.32ºC to 0.75ºC reduction; Cold season: 0.57ºC to 1.26ºC increase
Singapore	[8]	> 11.5ºC reduction (façade surface); > 3.3 ºC reduction, (ambient in front of facades)
Thailand	[9]	2.06ºC -7.2 ºC reduction (day time); 0.56ºC reduction (night time)
Hong Kong	[10]	0.3-6.7°C reduction
Malaysia	[27]	6.4 ºC reduction
Malaysia	[28]	0.8°C reduction
Indonesia	[29]	0.29 ºC – 0.83 ºC reduction

4. Discussion

The significant implications of heavy climate conditions, especially heat in the classroom that affects students' learning routines, have necessitated the development of appropriate design strategies for VGS within climate adaptation measures. Despite the fact that a lot of scholars have addressed this topic, there is still a scarcity of study on students' health and well-being when engaged in school-related activities. This study presents a number of adaptation strategies, primarily focused for VGS incorporation into school design in Malaysia, to help overcome the gaps. Many scholars, stakeholders, and politicians have proposed adaptation options that align with the recommendations in this publication (Table 3).

4.1. Reaching the Interior Thermal Comfort in the Classroom

Research in the past suggested that VGS might act as a wind barrier, increase ventilation, control humidity, and provide shade from direct sunlight that entered into the classroom. For optimal thermal comfort in a room, other factors such as building orientation and the type of VGS installed, as well as ventilation, openings, roof materials, cross ventilations, and other types of building materials, should be considered [3,4]. According to the Department of Standards Malaysia, the total effects of VGS application can reduce temperature to human comfort level (DOSM). Interior design temperatures and relative humidity range from 23°C to 26°C and 60 to 70 %, respectively [14].

4.2. Increase Students Schooling Performance

Students' sensitive sensory perception of nature will further inspire positive behaviours and boost learning outcomes. Having access to outdoors and green helps reduce the stress of overcrowding in classrooms and usual routines for the students. A further enhancement in the façade's, acoustic performance, oxygen (O2) stimulation, greater sun shades and many more paybacks will allow students to concentrate better in the classroom as well. Greenery can increase the performance and perception of urban environments. When implemented in a school or community, VGS can improve student and school performance, as well as boost community pride in the community [8, 21].

4.3. Enhance Students Health and Well-being

Students' health and well-being can be improved through the use of VGS in public schools, especially in metropolitan areas, by creating a therapeutic environment with landscapes and vegetation. Aside from modernising facades, this will improve public school images by lowering heat gain while reducing electricity usage [21].

Table 3. Methodology established of social well-being analysis for the installation of VGS in public schools. [4-8, 21].

	Consequences for Students, Teachers, and Schools.					
Main VGS benefits	*Cognitive and learning performance*	*Concentration improvement*	*Increase School image*	*Teachers' Performance*	*Sensory experience*	*Protection and security*
Thermal comfort	x	x		x		
Visual and aesthetic	x	x	x		x	x
Acoustic performance	x	x		x		
Improvement of health and well-being	x	x			x	x

5. Conclusion

The effect of VGS on the public-school environment is having a significant impact on thermal comfort. VGS are available in several categories, such as the one that is specifically made for educational institutions. According to the review, the VGS benefits not only provide scientific proof for greater classroom thermal comfort and indoor cooling in tropical climate, and moreover contribute towards the health and social well-being of students and teachers, hence helping students to learn more efficiently. The use of VGS may be advantageous to public schools in Malaysia, especially classrooms design that depend on passive cooling measures. However, there is a lack of data and in-depth studies about VGS's application and implementation in public schools in Malaysia and all around the world. In addition, the six VGS techniques (Table 3) are recommended for further design and research of potential study.

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