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Editors: Kirsty Christer, Claire Craig & Paul Chamberlain

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Volume 1

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Indoor Living Wall: educational tool for improving eco-health awareness in public school

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ABSTRACT The increasing urbanization trend may affect negatively people's health due to the lack of natural areas. Younger generations carry out many daily activities in indoor spaces, such as schools, where the quality of indoor environment could be poor. Recent studies assert that the application of vertical greening in indoor spaces improves the quality of indoor air and provides several benefits for occupants' wellbeing. Vertical greening systems are included in the set of Urban Green Infrastructures (UGI) that apply nature-based solutions and promote an ecological approach for the improvement of built environment. They also offer the opportunity to develop educational activities focused on ecological approach in urban areas. Urban environmental education involving green infrastructures helps to rise people's awareness regard the importance of environmental quality for their wellbeing. This paper investigates the opportunity to consider indoor living wall as complementary education tools to promote (non-) formal education and ecological literacy. It investigates how the development of green curricula activities using indoor living wall can promotes the understanding of the cross-dependence between human health and the quality of indoor environment.

Keywords: school living wall, eco-health, ecological literacy, indoor environment.

Introduction

The rapid and constantly increasing of urban population stresses the need to focus on the quality of life in big cities. In 2009, for the first time in the human history, the number of people that are living in urban areas surpassed the rural population. The United Nations (2017) estimates that 70% of global population will live in cities by 2050 and that the urbanization trend will increase especially in Asian countries. Sustainable Development Goals - SDGs (United Nations 2012), especially the SDG 11 - Cities & Communities, highlight the need to adopt effective solutions to mitigate harmful effects and to improve the quality of urban environment. The high concentration of people requires to change the structure of urban areas and these transformations cause consistent impacts on environment and on human health and wellbeing. Considering the ongoing intensification of worldwide urbanisation trend, the holistic interdependence between natural ecosystems and human health should be taken into consideration. The WHO (1948) defined human health as 'a state of physical, mental and social wellbeing and not merely the absence of disease or infirmity'. Sustainable development concept requires a more holistic understanding of environmental quality and human wellbeing. The positive effects of urban green areas on human health are recognized reducing psychophysical stress, inducing positive emotions and facilitating the renewal of cognitive resources (Figure 1) (Harting et al. 2011).

Figure 1: Royal Botanical Garden in the Central Business District of Sydney (Australia) (Authors' picture, 2019). Urban parks provide several benefits for urban population in terms of carbon sequestration, microclimate regulation, wildlife habitat provision, noise reduction, social cohesion and mental wellbeing.

Biofilia in urban context

The *Biophilia Hypothesis* asserts that human respond positively to natural environment (Kellert, 1995), but ordinary life in metropolitan areas has less and less direct experience with nature. Indeed, the majority of people spend 90% of daily time in indoor spaces, compromising their physical and psychological health (Liu et al. 2019). As cities are still growing, increasing attention has been given to Urban Green Infrastructure (UGI) and green spaces (Van den Bosch and

Nieuwenhuijsen, 2017) as key elements to maintain human health and wellbeing and to improve a sustainable and ecological approach in planning urban areas. Loh et al. (2020) have discussed the necessity to change the common 'business as usual' approach to architecture and design and to adopt 'more-than-human' perspective, moving away from a reductionist thinking in performing built environment toward systemic one. UGIs and green areas provide regulating, supporting and provisioning ecosystem services to increase sustainability in built environment, but also cultural ones focused on science-based and nature-experience education.

Vertical greening functions in indoor environment

The *biophilic design* attitude applied to interiors is becoming an important strategy to improve the ecological dimension in high urbanized cities and to create healthier spaces (Beatley 2011). Vertical vegetated surfaces, well known as green walls or living walls, are included into the strategy for greening cities providing important ecosystems services (Table 1) (Neonato et al. 2019).

Table 1. Ecosystem services provided by outdoor and indoor vertical greening systems.

Ecosystem Services	Benefits	Indoor	Outdoor
Supporting	Habitat for insect (urban ecological corridors)		x
	Biodiversity of plant cultivars	x	x
	Nutrient cycle: Photosynthesis	x	x
	Pollination		x
Regulating	Carbon sequestration and climate regulation	x	x
	Stormwater drainage management		x
	Removing water pollutants	x	x
	Improvement of air quality	x	x
	Building energy efficiency	x	x
	Noise reduction	x	x
	Reduction of 'heat island effect'		x
	Relative humidity regulation	x	x
Provisioning	Food production	x	x
	Medical resources	x	x
Cultural	Ornamental resources	x	x
	Natural landscape heritage		x
	Aesthetic purpose in interiors	x	x
	Therapeutic or Eco-therapeutic (mental health)	x	x
	Science and education	x	x
	Recreational and community experience	x	x

Living walls incorporate vegetation in their structure using different kind of substrates as growing media for plants. They can be organized in modular or continuous structure. Modular living wall systems are different typology and they differ by weight, composition and assembly (Manso and Castro-Gomes 2015). In all cases, growing media and irrigation system are kept separate from the

construction material by a water-proof membrane to ensure the integrity of the wall structure (Dunnet and Kingsbury 2008).

Figure 2: Examples of indoor and outdoor living wall systems, University of Technology Sydney (Authors' pictures, 2020).

Living wall systems in urban environments are a space-saving strategy to reintroduce natural elements, not competing for land-use because they exploit existing vertical surfaces. Recent studies assert that living wall systems are effective solutions not only for ornamental purposes, but also for the improvement of indoor air quality (IAQ), using plants ability to reduce the concentration of airborne pollutants in interior spaces, such as carbon dioxide, benzene, formaldehyde and other organic volatile compounds (Brilli et al. 2018).

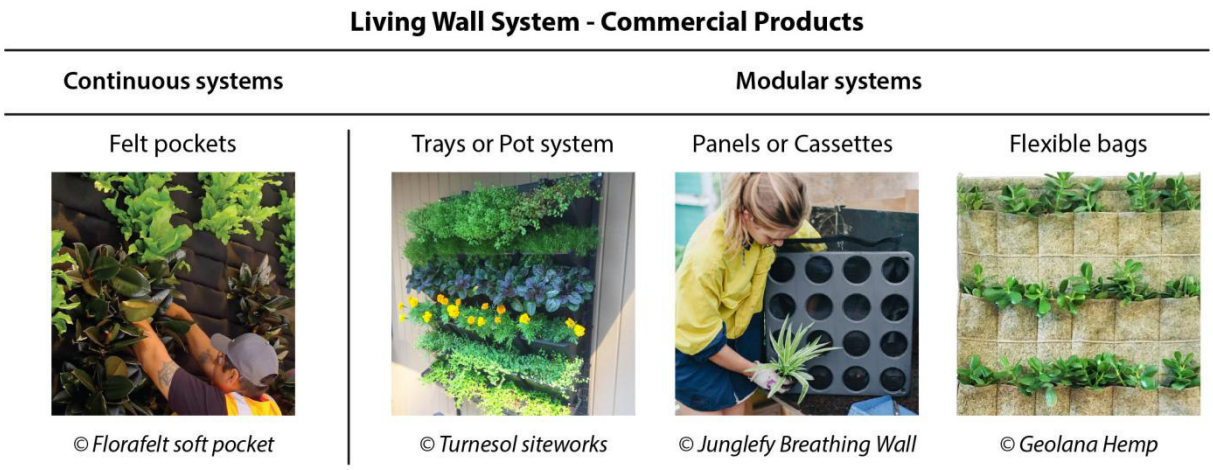

Figure 3: Examples of commercial products per type of living wall structure.

Children and young students usually spend many hours per week in a school environment and often they may be exposed to poor indoor air (Marchland et al. 2006). Moreover, children in deprived neighbourhood may lack access to green areas and they are forced to spend the most of their free time with indoor activities. This habit also increases the risk to develop health diseases, such as depression, negative emotions and low cognitive attention. The application of living wall system into school mitigates effects of indoor air pollution (Tudiwer and Korjenic 2017), it gives the possibility to increase the daily nature exposure, increasing cognitive functioning and attention (Taylor et al. 2002), and to develop educational programmes focused on nature-based solutions for urban environmental quality.

The importance of Eco-Literacy to support urban ecology

The complexity of urban contexts raises problems related to public health, liveability, resources and outputs management, environmental impact and quality of services. The discipline of *Urban Ecology* promotes an interdisciplinary approach to investigate interactions between human living and the urban ecosystem, underlining that human wellbeing strictly depends by ecosystem health (Richter & Weiland, 2011). The World Health Organization (WHO) considers urbanisation one of the most important challenge of the 21st century (2014) associated with the increase of stress, poor mental health and respiratory disease. Urban environmental education might help to cultivate ecological attitude in citizens, and especially in young people. Environmental education through UGIs gives the opportunity to understand basic principles of ecological systems and their application into built environments. It also encourages awareness, knowledge, skill development and participation in problem solving for environmental issues. In other words, it gives a chance to become *ecoliterate*. Ecoliteracy is defined as the understanding of principles of nature and the using of them to create sustainable human communities (Orr 1992; Capra and Luisi 2015). Raising citizens ecological consciousness may encourage changes in behaviour that create attention on nature-based solutions and greening strategies, involving urban communities to improve more healthy environment.

Greening school: multifunctional purpose of indoor living wall

A indoor living wall is proposed to be installed in a primary school in Mirafiori Sud district (Turin, Italy) into the wider framework of the ongoing proGIreg project (2018), which has the goal to implement nature-based solutions for post-industrial urban regeneration. The proposal is considered a pilot project to improve indoor environmental quality of suburban schools and to promote *civic ecology education* in young students.

Figure 4: Map of Mirafiori Sud district and main land-use areas.

Mirafiori Sud is a working-class district in the south of Turin that has developed around the automotive industry ex-FIAT Mirafiori, nowadays known as FCA. The primary school is in the western side of the district, in a residential area rich with connecting green areas and gardens, but also really close to the industrial one. The decision to install an indoor living wall was taken to use plant-based solutions for IAQ, but also to involve students in informal learning activities based on the interaction with indoor plants. The aim is to encourage young students to develop collaborative interaction, responsibility and hands-on experience in indoor plant care and vertical gardening. A indoor corridor, used also as recreational area, has been selected to host the indoor living wall, facilitating the access of students from classrooms. The location has been selected based on light requirements and water provision (through automatic irrigation system). Substrate-based pot-plant modular living wall (12m^2 of total surface area) is considered the most suitable structure to allow students interaction and reduce security hazards. Indoor ornamental plants recommended for air phytoremediation should be placed on the top part of the indoor living wall, while bottom cassettes are mainly dedicated to indoor vertical gardening (e.g. planting herbs) that requires students active involvement in planning and maintaining actions (Figure 5).

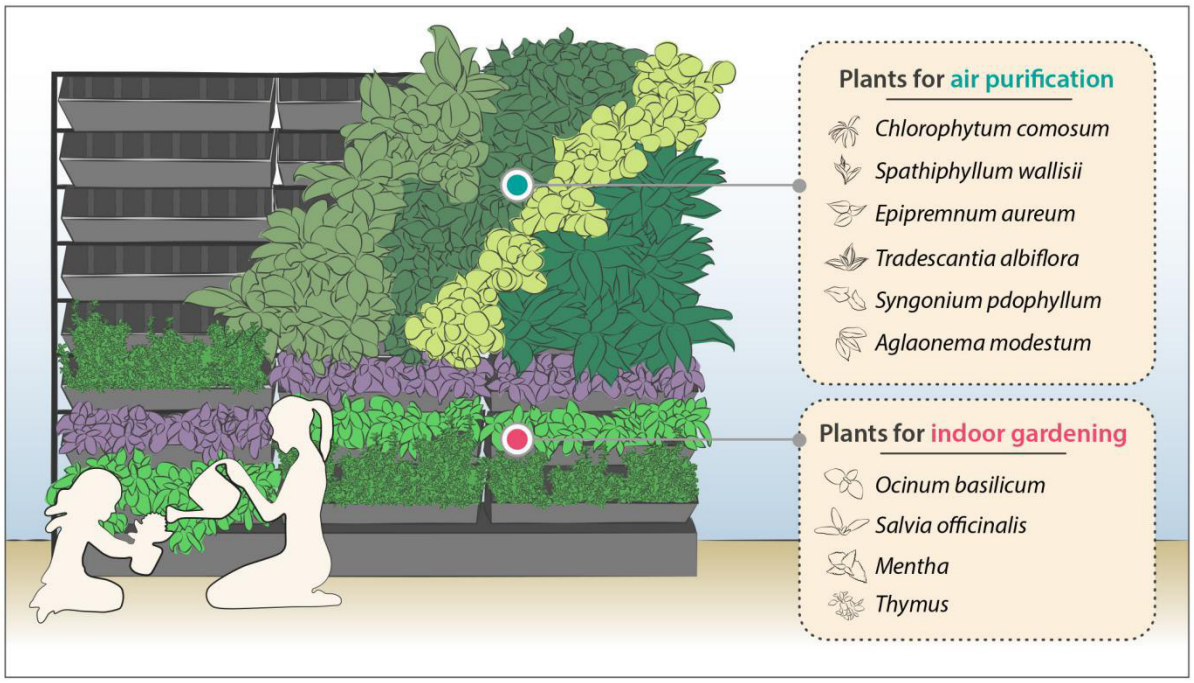

Figure 5: Indoor living wall scheme with indication of pant species.

Building civic ecology education and ecoliteracy skills

Indoor living wall in schools has the potential to inspire students in ecological thinking through the integration of project-based learning modules. They promote students interaction with indoor greening systems and create the opportunity to implement a nature-based learning curriculum. Indoor living wall becomes an education tool for informal education activities to improve knowledge in science, technology, arts and culture. It gives the opportunity to learn about the importance of vegetation in interiors: students develop critical reflection about *why* and *how* plants can improve indoor environments and learn practical skills to facilitate the integration of vegetation as a

component of interior environments. Vertical greening is high technical solution applied to 'phytomitigate' negative effects of strong urbanization (Kennen and Kirkwood 2015). It demonstrates how technical skills can support plant growth to increase urban resilience. Students have the opportunity to learn more about plant physiology and ecology in urban environment through conversation with experts and specialists. This framework define that environmental education model can be developed *in*, *about* and *for* indoor living walls.

Education 'in' indoor living walls

Education *in* indoor living walls refers to the opportunity to organize placed-based learning, hands-on and experience activities in classroom and also after-school. The school's living wall is considered as *living lab* to experiment vertical indoor gardening and to translate abstract ecological principles into practical ones. Place-based learning in indoor living walls helps to integrate informal education model into traditional curricula and to build sense of place using school spaces for unusual community-based activities.

Education 'about' indoor living wall

This refers to the knowledge improvement of benefits provided by indoor greening in term of IAQ and psychological benefits. Specific lessons focus on air quality, sources of indoor air pollution, human health, botanical and physical aspects of indoor plants, physiological mechanisms involved into the degradation of airborne pollutants, living wall benefits, indoor gardening and technical aspects required for vertical greening systems to create healthier indoor environment. Indoor living walls could be considered as a complementary tool for school gardening programmes that are already active in the primary school. Students could also experiment with indoor agriculture through cultivation of some edible plants or herbs, especially during autumn and winter season. Learning plants requirements that are affordable for indoor environment fosters improved knowledge about the integration on nature in interior spaces.

Education 'for' indoor living wall

This refers to the need to provide knowledge and skills to make users able to do appropriate maintenance. Education activities should be organized to promote students participation and involvement. Information about plant care, pests, diseases, watering, lighting and fertilizers could encourage students to develop critical thinking skills to maintain ornamental and functional properties of the living wall system. Looking at other initiatives, such as the 'It's Time to Grow Up' project (2020), actions to improve the knowledge transfer about vertical greening systems in urban environment are essential for the involvement of local community and citizens groups. Informal education *for* indoor living wall could build cooperative social skills and promote community-based learning activities through the participation of students families and local neighbours. Community-based and project-based learning promote action skills to mitigate urban environmental problems that impact human wellbeing, considering also social and cultural aspects (Ballard and Belsky 2010).

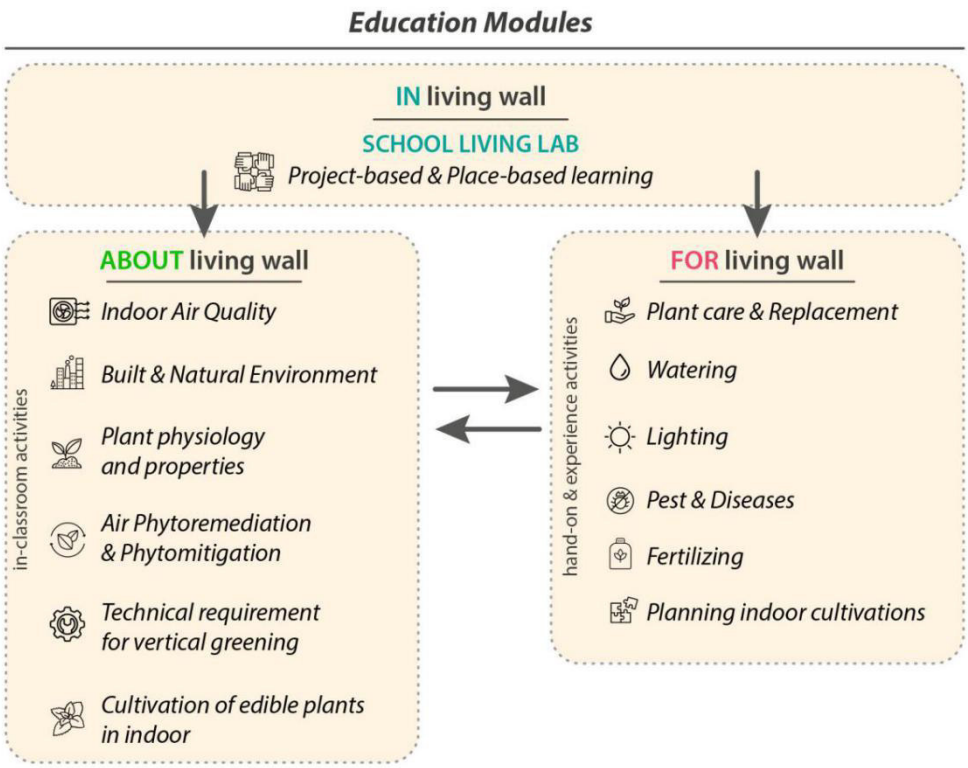

Figure 6: Learning activities that use indoor living wall as education tool.

Conclusions

Improving ecological vocabulary and knowledge to be ecoliterate

Indoor living wall provide opportunities to students to interact with an example of UGI and to reflect about their role in the improvement of ecology in, of and for the urban environment (Pickett et al. 2016). Environmental education activities based on observing, analysing and experimenting indoor living wall improve students understanding of nature-based and phytotechnology solutions benefits on human wellbeing mitigating climate at city scale. Improving young students consciousness about ecosystems services provided by UGIs could promote individual appreciation of nature and foster more positive attitude towards ecological approach in urban environment. Through practical interaction and conversation with experts, students have the opportunity to learn more about the differences between natural and built environments and about UGIs role for sustainability and resilience of cities. Informal education encourages students to stay more in connection with living systems (plants) creating recreational moments that have positive effects on perceived stress reduction and on metal health. As well as improving air quality, indoor living wall systems contribute to teach basic information about biophilic urban strategies and ecological approach to design more sustainable interior spaces. In addition, recent global disruptions linked to the spread of Covid-19 highlight the need to re-think some informal education activities, that include community-based and project-based learning strategies, due to social distances measures. This scenario requires the use of virtual tools to improve ecological consciousness and environmental education programmes. On the other hand, restrictions on people's movement encourage them to think about the importance of nature local accessibility, such as parks, and of indoor greening.

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