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Indoor Environment Quality (User Comfort, Health and Behaviour)

Greenery for a university campus: does it affect indoor environmental quality and user well-being?

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Abstract

In an indoor environment, greenery plays an important role for the quality of space as well as for the users' psychological well-being, comfort and health. The purpose of this study is to evaluate the feasibility of installing an indoor green wall at a university campus (Politecnico di Torino, Italy), taking into account users' perception and preferences. The paper builds on a questionnaire based survey developed in order to assess: the relationship between vertical greening systems and users' sense of well-being and comfort; the best indoor location for a green wall and its influence on the environmental quality. The paper presents the questionnaire survey results and analyses the strengths and weaknesses of vertical greenery in respondents' opinion.

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Keywords: green walls, environment quality, psychological well-being.

1. Introduction

1.1. Overview on environmental and psychological benefits of greenery

The technologies related to the use of building integrated vegetation, such as vertical greening systems, are able to

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provide different beneficial effects both from environmental and psychological point of view.

These solutions, also named green walls or vertical gardens, have a positive impact on indoor environmental conditions: they contribute to the acoustic comfort, reducing reverberation of sound and increasing absorption at low/middle frequencies [1]; adsorb indoor pollutants, such as Volatile Organic Compounds, thus improving the air quality [2], improve the thermohygrometric conditions thanks to the evapotranspiration of the plants [3].

Moreover, the integration of greenery in indoor environments has an important role for the psychological well-being. People generally perceive areas with vegetation and natural elements more positively than those without [4, 5] and these considerations can also be transferred to the building integrated vegetation. Contact with nature has therapeutic effects [6], evokes positive emotions [7], promotes recovery and restoration from stress [8, 9], affects social cohesion [10]. Particularly with regard to workplace, greenery improves users' satisfaction, enthusiasm and concentration, it increases the ability to generate creative ideas, and it reduces frustration and absenteeism as well [11, 12].

1.2. Purpose of the research

The purpose of the research is to assess the feasibility of installing an indoor green wall in one of the architecture university campus of the Politecnico di Torino, Italy, taking into account users' perception and preferences. The research is related to an enquiry that the Politecnico di Torino is carrying out on the quality of its university spaces, in collaboration with the Department of Architecture & Design and Growing Green srl, an academic spin-off engaged in designing, manufacturing and monitoring modular Living Wall Systems (LWSs). LWSs are vertical greening technologies in which plants grow directly on the vertical surface [13, 14].

The research is composed by the following phases:

- Phase_1: detailed analysis of the social, environmental and economical benefits and costs of a living wall in order to determine the overall feasibility;
- Phase_2: identification of the size, layout and location of the living wall if the feasibility is proved.

This paper reports a part of the outcomes related to the Phase_1, in particular those related to a survey addressed to the campus population. The survey adopts a methodological approach based on previous literature studies and it is structured as a questionnaire [15, 16, 17].

The questionnaire was developed in order to asses:

- the level of knowledge in relation to green wall technologies and especially the perceived benefits and limits of such technologies;
- the relationship between vertical greening systems and users' sense of well-being and comfort;
- the best indoor location for a living wall and its influence on environmental quality.

2. Methodology

2.1. Site and population

The Lingotto university campus (Politecnico di Torino) was selected as a potential location for a living wall installation due to the following reasons: a Master of Science in architecture is taught there; a great number of students attend it daily.

The research targeted those students who visit the Lingotto at least once a month. The population consisted of students of MSc degree programme in Architecture Construction and City and the MSc in Architecture for Sustainable Design. The sample was formed by 136 participants.

2.2. Structure of questionnaire

The questionnaire was organized as shown in table 1 and it is based both on single-response and rating-scale items.

Questions #1 to #3 collect general information about the respondents. Questions #4 to #8 focus on understanding how many respondents have previous knowledge on green wall and what their perception is about the benefits and limits of this technology. Questions #9 to #16 investigate if respondents approved with having a green wall in the campus and if so, where - atrium/food court, corridors, study rooms, classrooms. Pictures and rendering of university spaces with and without vegetation are also included (Fig. 1).

A pilot study (pre-testing) was done to improve, complete and revise the original version of questionnaire.

Table 1. Structure of questionnaire.

Questions	**Response/Rating scale**
#1 Age	18-25; 26-39
#2 Gender	Male; Female
#3 MSc degree program	Architecture Construction and City; Architecture for Sustainable Design
#4 Knowledge of LWS	Yes; No
#5 Level of knowledge about LWS	Insufficient; Good; Expert
#6 Learning environment about LWS	Magazines; University; Web; Events
#7 Perceived benefits of indoor LWS (aesthetic value, acoustic comfort, air quality, stress reduction, concentration, productivity, interaction with nature, thermohygrometric control)	Level of preference from 1 to 5
#8 Perceived limits of indoor LWS (insects, allergies, bad smell, humidity, maintenance, high costs, building's damage)	Level of concern from 1 to 5
#9 Attendance at the campus	Once a day; Once a week; More of three times a week; Once every two weeks; Once a month
#10 Reasons to attend the campus	Study; University lessons; Events
#11 Environmental evaluation of the campus	Bad; Mediocre; Good; Excellent
#12 Position about LWS installation at the campus	Contrary; Partly contrary; Neutral; Partly agree; Agree
#13 Preference about four locations (atrium/food court, corridors, study rooms, classrooms)	Level of preference from 1 to 5
#14 Best indoor location for LWS	From 1st to 4th place
#15 Perceived benefits of campus' LWS (aesthetic value, acoustic comfort, air quality, stress reduction, concentration, productivity, interaction with nature, thermohygrometric control)	Level of preference from 1 to 5
#16 Perceived limits of campus' LWS (insects, allergies, bad smell, humidity, maintenance, high costs, building's damage)	Level of concern from 1 to 5

a

b

Fig. 1. Exemple of pictures included in the questionnaire: the atrium/food court without (a) and with (b) the living wall.

2.3. Data analysis strategy

The data collected from the questionnaire were analyzed by a statistical software. The frequency of the replies to each question was calculated according to the descriptive statistics. Column graphs were used to summarize and present the data. Moreover, the relationship among some variables were studied.

3. Results and discussion

The following paragraphs illustrate the results of the questionnaire divided for objectives.

3.1. Level of knowledge in relation to green wall technologies and perceived benefits and limits

The questionnaire was distributed to 136 students: 47% male, 53% female, mainly aged between 18-25 years old (questions from #1 to #3). With regard to the question #4, all the respondents confirmed that they were familiar with the living wall technologies but no one judged to have an expert knowledge: 45% of respondents claimed to have a good competence while the remaining 55% declared it was insufficient (question #5). Moreover, 83% of students said to have become aware of the existence of vertical greening systems thanks to the university, followed by the web, then magazines and finally a minority through exhibitions or events (question #6).

As regards the perceived benefits of indoor greenery (question #7), the aspects evaluated with maximum score (score 5) were: at the top the interaction with nature, followed by the thermohygrometric control, and then the increase of aesthetic value and stress reduction as well as the improvement of air quality. In relation to the drawbacks of green walls (question #8), the majority of the respondents gave the maximum rate (score 5) to the high level of maintenance, followed by the high initial and maintenance costs which turn out to be the technology's main concerns. The presence of bad smell and damage to the building obtained the lowest score, so they don't represent an issue for respondents. The graphs in figures 2 e 3 show the results of these analyses.

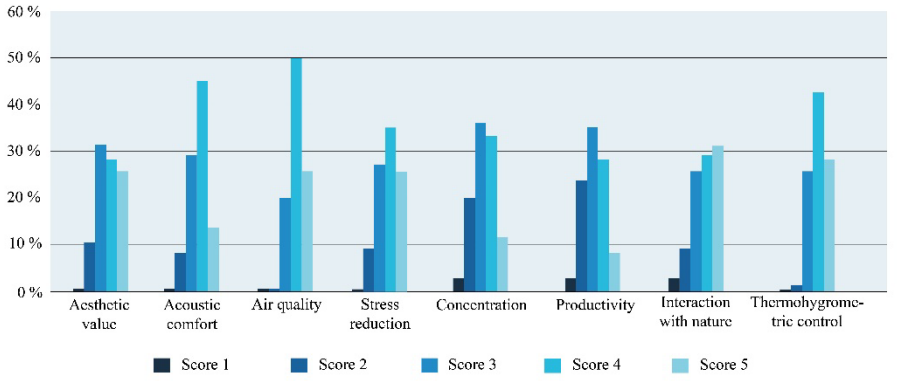

Fig. 2. Results of question #7 (perceived benefits of indoor LWS).

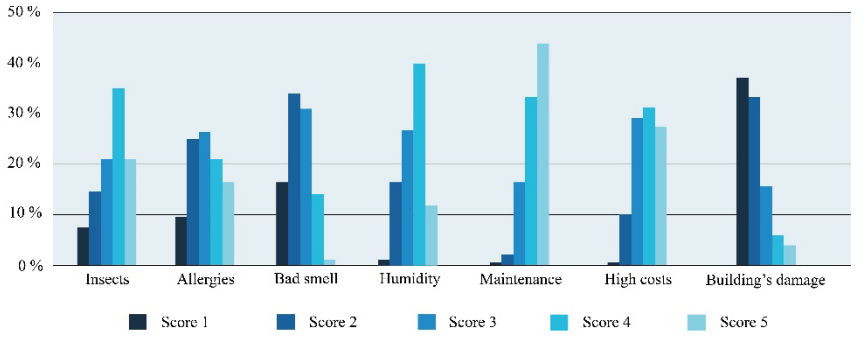

Fig. 3. Results of question #8 (perceived limits of indoor LWS).

3.2. Relationship between vertical greening systems and users' sense of well-being and comfort

Another focus of the survey was the environmental evaluation of the Lingotto university campus, which is visited daily by 58% of the students (question #9). The 51% of all interviewees evaluated positively the quality of spaces and equipment, followed by 44% who judged the location as mediocre; few people considered it bad, while only one respondent claimed it was excellent (question #11).

Starting from this analysis, the respondents were asked their opinion (question #12) about the installation of a living wall system right inside the building. 44% widely approved and 36% partially approved the installation of a green wall in the building, some were neutral and a few partially disapproved, as shown in figure 4.

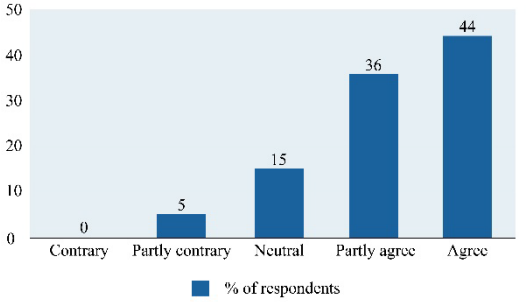

Fig. 4. Results of question #12 (position about LWS installation at the campus).

For the campus population who approved or partly approved the greenery project at Lingotto university campus (question #12), the major benefits highlighted were the increase of the aesthetic value and stress reduction (question #15), but the biggest weaknesses identified were insects, high level of maintenance and costs (question #16). Even the respondents that were contrary or in part contrary to the project expressed the same concerns, maintenance being the major challenge, followed by the high costs, the presence of insects and the increase in humidity.

3.3. Best indoor location for a green wall and its influence on environmental quality

The respondents were shown some pictures that illustrated the current state of four locations in the building and renderings with a living wall installation. They were asked to express a preference from 1 to 5 for each alternative (question #13) and then draw up a ranking based on their own judgment (question #14).

The graph in figure 5 includes only the answers of those who approved/partially approved the technology in the question #12 (80% of the respondents). They chose the atrium/food court (48%) as the best indoor location for the campus living wall. Other alternative locations chosen by the minority were corridors (30%), study rooms (11%) and finally classrooms (11%). For the respondents who chose the atrium/food court as the best indoor location, the most important strengths were the increase of the aesthetic value (43%) and stress reduction (35%), recognizing also a psychological aspect for the food court greenery. As to the weaknesses, the majority highlighted the maintenance service (45%) and the high costs (47%).

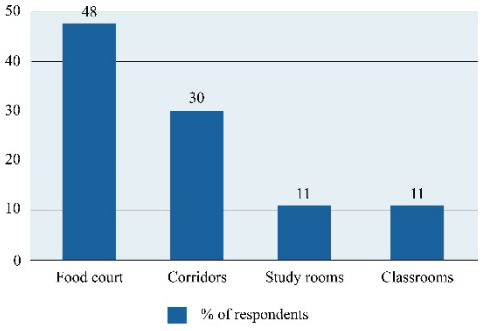

Fig. 5. Results of question #14 (best indoor location for the LWS) related only to the students that approved/partially approved the technology (question #12).

4. Conclusion

The survey results have shown that campus locations with greenery systems are perceived better and considered more attractive than those without such amenities, although some respondents still express some concerns. Most of the students believe that this kind of project could improve the aesthetic value of the campus and the interaction with nature might affect the individual's psychology thanks to the stress reduction. The main concern is related to the constant need of maintenance and the high costs for installation and maintenance.

In order to extend the scope of the research the questionnaire will be administered also to professors and other staff who attend the campus.

In addition to the social analysis, the next phase of the research will be aimed at assessing the living wall system's economic sustainability. A cost-benefit analysis (CBA) will be carried out in order to choose the type, the size, the layout and the technological details for the indoor living wall at Lingotto university campus.

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