INDICATORS FOR EXISTING BUILDINGS ASSESSMENT

Application to an office building in the perspective of users

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Extended Abstract

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Abstract: The concept of the term performance has become specified and gained use when applied to the assessment of buildings, fundamentally requiring a correct correspondence between what is required (demand) and what it is offered (supply). Thus, this thesis aims to list a set of indicators that will evaluate the performance of a building. Its second objective is to validate part of the indicators that make up this list - those that relate to user satisfaction. A set of indicators is developed to assess the performance of a building; those indicators are separated into three different approaches: technic, environmental and economic. Each indicator is subjected to one or more measurement techniques: documentation review, surveys to users or maintenance representatives, visual inspections and testing (laboratory or in situ). The field work is applied on an office building, being preceded by the validation of a set of indicators related to the assessment of the user satisfaction. In this work it was possible to conclude that it is necessary to make the organization of indicators in specific groups and, when required, through an iterative process. One should understand, the better adjust of each indicator, not forgetting to take into account their limitations and what means to mobilize its application measurement technique.

Keywords: Building performance; in-service buildings; performance indicators; user satisfaction evaluation.

1. Introduction

"The Performance approach is (..) the practice of thinking and working in terms of end rather than means" (Gibson, 1982).

The concept of performance is a term applied in different areas and different definitions. It can be taken into accordance with the area in question (Neely, 2002).

In 1760 BC, has been compiled the first document linked to the performance of building, in order to ensure the structural safety (Foliente, 2000), having being built the first issue of this methodology in the twentieth century (Gross 1996).

In order to boost innovation and globalization in the construction industry, there is a need to deepen the theme of performance applied to this area. Thus, several organizations pored over the issue, developing fundamental studies on the evolution of performance in this field, namely CIB ("International Council for Research and and Innovation in Building and Construction") (1964), initiated in 1970, ASTM (1986) ("American Society of Testing Material") and the Technical Research of Finland (2004).

In 1984, a standard, ISO 6241 (1984), arises which presents a set of requirements in buildings. This standard defines performance as the performance of a product (building or its constituents), which is directly related to its use. The development also serves as a support for checking the efficiency of operation of a building, essentially in countries where the performance is considered a fundamental aspect.

The concern with a better sustainability leads CIB, in 1995, to the development of a project on this topic, which discusses the concept of sustainable development in the construction industry, exposing future benefits involved, through a set of strategies and recommendations for good practice implemented on this sector (Silva, 2007). Several organizations conducted studies that are related to the performance and sustainability of buildings, including the GBC ("Green Building Challenge, International"); iiSBE ("International Initiative for Sustainably Built environment"); SB Alliance ("Sustainable Building Alliance"); WGBC ("World Green Building Council") and the LiderA Portugal (Nilsson & Cole, 1998; LEED, 2009; Pinheiro, 2009; Larsson, 2012; Mateus & Bragança, 2010).

Portugal has been developing the concept of performance. However, the existing information is still scarce and free of specific rules and regulations. That fact makes the process more difficult when trying to improve the performance of a building. The issues in this area, providing a further study, refer to qualitative issues associated with adaptation to use, which are considered the occupancy rate and adaptation to space (Santos, 2008).

The development study of the work of these organizations allows for reflection on the subject in question, focused on performance evaluation of buildings in service and more specifically in buildings with a particular type of use, offices. The development of these different lists of performance indicators allow profiling the assessed building, from a global perspective of operation, and enabling a knowledge of its current state. With the results of the evaluations made it possible to understand what the existing needs and demands are.

The aim of this work is to develop a list of indicators that measures the performance of buildings in use, associated with technical, environmental and economic aspects. If you make the application of all indicators, it is possible to check the current status of the building, comprising aspects in need and / or that need to be adjusted. This work does not validate all the selected indicators in the list, it is only applied for those that require an assessment of users for evaluation.

Building Performance

The concept of performance can be defined in various ways, as well as approached from different perspectives depending on the intended purpose. Neely (2002) defined this concept as a measurement of quantitative value or an expression; the result (output) of a share (created quantifiable content); the ability to achieve or promote the creation of a new result (output), with the aim of satisfying customers / users; a comparison between results obtained with a reference standard; a result that surprises expectations; a process that involves an action associated with the same results.

According to PeBBu (Szigeti and Davis, 2005), the concept of performance is basically composed by two questions:

- the use of two languages: i) the necessary requirements for good performance (demand) and ii) the ability to satisfy these requirements (supply);
- the need to verify and validate the results, taking into account the desired performance.

Professionals have adopted as terms of demand and supply markets to refer to the requirements requested by customers and the responsiveness to their requirements (Ang G. et al, 2001.); (Blythe & Worthing, 2001); (G. Davis et al, 1993a).; (G. Davis et al, 1993b); (Gibson, 1982); (Gregor & Then, 1999) – Figure 1.

One way to match the *demand* and *supply* is through a performance evaluation. This review is essentially a systematic research process, not only the demand of human needs as well as the performance and management of a building. A evaluation of a technique performance can be used, in one way where parameters, equipment and knowledge lead to an objective; for the other way, considering the viewpoint of users, is focuses on a more subjective perspective, which can vary by individual(Reis & Lay, 2002).

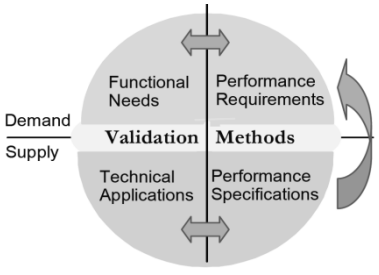


Figure 1 - Translation and Validation (Szigeti & Davis, 2005)

The results obtained regarding the performance will translate the responsiveness of the building to the demands and requirements imposed. Thus, the assessment of performance is carried out taking into account the presented features. In the definition of a requirement and its criteria, it is necessary to establish not

only what is acceptable, but also what it is essential to understand the desired level of performance, and the element that supports data which can be obtained through a set of trials (Galvão, 2009).

The performance evaluation can contribute very effectively and in a relevant way in the different phases of a building (Cooper, 2001):

- Project phase;
- Stage management;
- Sustainability development.

A lot of organizations have developed methods for evaluating the performance of buildings systems. In particular, CIB, ISO 6241, ASTM, VTTProp, these organizations focus more on overall performance of the building. According to studies carried out by these organizations it has begun to emerge performance assessments of buildings, also considering a perspective of sustainability, where it is noted the work of the GBC LEED, LiderA, SBTool^{int}, SBTool^{pt,} BREEAM, etc. For the analysis in this paper of each organizations studied, it was possible to conclude that ones focused on building performance organizations consider more technical aspects (structural, physical, chemical) instead of addressing the sustainable performance of buildings, which focus on criteria related to social, economic and environmental aspects (biodiversity, pollution, amenities, outdoor accessibility). Nevertheless, it is noteworthy that despite different perspectives, all organizations often consider aspects related to the following criteria: i) Lighting, ii) thermal iii) acoustic, iv) air quality; v) adaptability; vi) emission of gaseous and vi) energy pollution.

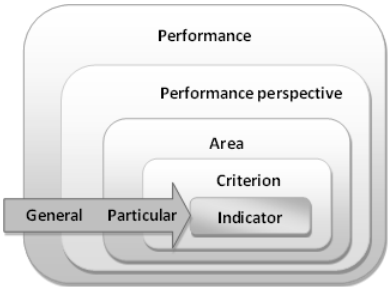
The service performance evaluation can be done in different ways. When it comes to the practical assessment of existing elements, which aims to analyze specific characteristics, visual inspections are an option, and if not enough can be complemented by testing (laboratory or in situ) (Tavares *et. al.,* 2005) (Flores-Colen *et al*., 2006).

From the perspective of users, the type of review is a little different, not so objective. It can be seen that, to perform a performance evaluation, you must obtain knowledge of the activities of these users, as well as various technical aspects. There are several ways to formulate and achieve the desired results, reflecting the studies and the solutions adopted. The selected methods are accompanied by such technical documentation as well as records of the building under study (Cintra, 2001):

- Interviews with officials of the construction and its designers;
- Interviews with managers, users and residents of the neighborhood;
- Photographic records (identification and detail) and documentation of the main approaches;
- Charts records and documentation that make up a building (plants, among other disclosures)
- Exploratory visits (*walkthrough*);
- Development and implementation of questionnaires to be applied to users (considering technical issues and observations such users).

2. Methodology

This study explores a reorganization of *criteria* and *indicators* presented in each of these tables, linking them to a particular type of component performance and considering the life cycle of a including the use phase. In Figure 2 presents a schematic of the hierarchy, from the general to the particular, of the concepts related to the building performance: *performance*, *performance perspective*, *area*, *criteria* and *indicators*.



3.1 Figure 2 - Hierarchy of concepts that are considered in performance of a building

After an analysis of the information gathered, it is defined the concept of performance from different perspectives, the way that it is more appropriate to the nature of the intended work. The three perspectives of performance selected for this approach are:

- Technical;
- Environmental;
- Economic.

3.2 Performance area and criterion

Each perspective can address different areas, feeling the need to define, in an explicit way, each performance perspectives. It was performed a characterization of these perspectives in the following areas:

- Technical performance:
  - Technical properties;
  - Maintenance;
  - Usage properties;
- Environmental and Economic performance:
  - Environment;
  - Economic.

This study is intended to obtain information not only for understanding the current state of a building as the aspects that are found in greatest need, through a review of the performance of the building, thus allowing a process of further improvement.

The *technical performance* area defines the technical characteristics and specifications of materials (*technical properties*), the practice of maintenance actions (*maintenance*) and issues related to the users of a building (*usage properties*), considering the aspects that directly interfere with them.

Nowadays, knowing that the environment poses to society an important component took into account this as one aspect to be addressed as the *environment.* The *economic* area is considered as a relevant issue because it is present at any stage of the life cycle of the building, depending on all the other factors involved.

Each *area* consists of a set of *criteria* that define it. The selected *criteria* are carried out by analyzing the tables developed by different organizations, for the overall performance and sustainability, as others have also mentioned it. Thereafter, develops the definitions of the various criteria that make up each strand. The grouping of these criteria was structured as follows (ISO, 1984; EC, 1989; CIB, 1993; ASTM, 1986; Hartkopf et al., 1993; VTTProp, 2004; Flores-Colen, 2009; Larsson,2012; Mateus & Bragança, 2010; BREEAM. 2008; LEED, 2009; Pinheiro, 2009; Maurício, 2011; France, 2005 Nilsson & Cole, 1998):

Technical performance

- Technical properties:
  - General properties : i) Mechanical and structural properties; ii) Surface properties (tactile); iii) Biological properties; iv) Physical and chemical properties; v) Thermal properties; vi) Optical properties; vii) Acoustic properties; viii) Electromagnetic properties;
  - Durability;
  - Safety: i) Fire safety; Structural safety.
- Maintenance:
  - Maintenance actions: i) Planned interventions; ii) Corrective and emergency interventions;
  - Management of operation and services;
  - Awareness and education;
- Usage properties:
  - Comfort, health and hygiene: i) Hygrothermal; ii) Acoustic; iii) Lighting and visual aspects; iv) Indoor air quality (IAQ); v) Comfort touch; vi) Spatial aspects; vii) Dynamic; viii) Hygiene;
  - Accessibility;

- Adaptability;
- Functionality;
- Outdoor amenities;
- Usage security.

Environmental and Economic performance

- Environment:
  - Integration of the soil: i) Natural ecosystems and biodiversity; ii) Landscape and heritage;
  - Environmental loads: i) Atmospheric emissions; ii) Effluents; iii) Energy pollution; iv) Solid waste pollution.
  - Resources: i) Water; ii) Energy; iii) Materials;
- Economic:
  - Indirect costs;
  - Cost of operation;
  - Maintenance cost;
  - Replacement cost.

3.3 Performance indicators

In each *area* it was explored a set of *criteria*, and for each *criterion* it was developed a set of *indicators*, based on study tables prepared by different organizations. So, each of the *criteria* defined above, corresponding to each *area*, are evaluated through a set of *indicators* that compose them. It is intended that the *indicators* that make up each *criterion* are the most representative as possible and that its application is made to the corresponding use of the building phase, even when it is not necessary to use the building for its implementation.

The indicators are used as tools for measuring the elements that are assessed. With the results obtained by these indicators, we can establish a relationship between these results and the objectives pursued. Hereby, it is possible to increase the performance of the elements that are in greatest deficit and further improve the performance of the building.

3.3 Metering Modes

The indicators used in each criterion are subject to one or more ratings. It was developed a method to evaluate the indicators, through a set of evaluation techniques and classification. Then, is explained the assessment techniques to be used for the indicators and the classification system adopted.

i. Valuation techniques

For each indicator there is a specific evaluation (s) technique(s). Taking into account the various techniques for evaluating the performance of buildings, are selected these as follows (Flores-Colen et al, 2006.) (Tavares et al, 2005.). (Cintra, 2001) (Riley et al 2009):

- Analysis and documentation of consultation;
- Visual inspection;
- Users surveys;
- Surveys for the entities of management of the building;
- Tests (laboratory or *in situ*);

ii. Classification

This study aims to obtain the value of performance of a building through the measurement techniques mentioned, and to achieve it there is the need to convert all the qualitative information in quantitative. The shape of converting information existing in different forms will vary depending on the measurement technique concerned. However, it is important to create a uniform and homogeneous way, in order to insure that the different technical evaluation is possible to reconcile with the results.

In this study we focus only on the measurement technique by conducting user surveys. The scale set for the development of these surveys can vary in the range of one (1) and 5 (five), one being the worst and five the best rating. The scale of one (1) to five (5) by having few numbers makes the most response more intuitive and simpler to understand, allowing for greater ease in storing the correspondence of each one of the classifications. It is also considered that in spite of being a small scale, it is

enough for the type of evaluation that is carried out, where the detail is not very relevant, but be aware of the user satisfaction in general. Also choosing a type of odd scale seems necessary by the existence of an intermediate value, 3 (three), allowing users to assign a rating of "reasonable / acceptable," because that would not be possible if the scale was pair. However, it is known that the consideration of such a scale can represent a trend in the allocation of the classification in the intermediate value, especially when surveys are too long and the respondent is already saturated. Given that, no further investigations took place and it was decided to go with kind of scale.

3.4 Users survey

On the impossibility of applying all the indicators defined in each strand, given its length and the fact that some of these require multidisciplinary knowledge, as well as the mobilization of specialist circles, it was selected for review only those indicators that measure user satisfaction. Users are the key element in evaluating the performance of a building, despite the inherent subjectivity; these are the main stakeholders in which operation meets their needs. So, after an overview of the tables prepared in each *area*, are defined the criteria, related to its indicators, to elaborate the survey. The criteria and the indicators that compose the survey are:

USAGE PROPERTIES

A.1 COMFORT, HEALTH AND HYGIENE

A.1.1 Hygrothermal

i) Air temperature

ii) Relative humidity

iii) Quality of overall system heating and cooling

iv) Ability to control individual equipment by users

A.1.2 Acoustic

i) Distribution of sound (air, vibration)

ii) Sound insulation (speech privacy, equipment, etc.)

A.1.3 Lighting and visual aspects

i) Level artificial lighting and natural

ii) Levels of task lighting - artificial and natural

iii) Contrast (lightness), ratio of brightness, contrast, color reproduction

iv) Visual appearance (interior and exterior)

v) Appearance of spaces and surfaces (aesthetics)

vi) The ability to control individual equipment by users

A.1.4 Indoor air quality

i) Odors

ii) Levels of ventilation: supply of natural air circulation

iii) Ability to control individual equipment by users

A.1.5 Touch

i) Properties of surface roughness, temperature of contact adhesion, flexibility

ii) Dissipation of static electricity

A.1.6 Space

i) Working space: space, furniture, surfaces, storage, seating, ergonomics

ii) Common workspace: partitioning, usable space, circulation and accessibility, signage, interface indoor / outdoor

iii) Interior amenities

iv) Ease of movement and flexibility

v) Utilities and services

vii) Recreation

A.1.7 Dynamic

i) Limitation of acceleration and vibration

A.1.8 Hygiene

i) Installation for hygienic users

ii) Water

A.2 Accessibility

i) Indoor accessibility

ii) Transport access by public transport

iii) Local bicycle storage

iv) Capacity for car park

v) Security in the pedestrian and bicycle circulation

A.3 Exterior amenities

i) Existence of amenities

A.4 Functionality

i) Ease in operation doors, window and control equipment

A.5 Adaptability

i) Adaptation to users' needs

MAINTENANCE

B.1 OPERATIONS MAINTENANCE

B.1.1 Planned interventions

i) Time Efficiency intervention

ii) Quality of intervention

B.1.2 Corrective and emergency interventions

i) Efficiency Duration of intervention

ii) Quality of intervention

The surveys are adapted for office buildings and intend to get a performance rating, assigned by its users. The main objective is to understand how much the building satisfies his users and what aspects present the best and worst outcomes, as well as to make it possible to identify aspects that need an improvement, by detecting situations with worst ratings. Users can assign each question a rating from 1 (very bad) to 5 (very good) or don't know / don't apply the attribution of "don't know" or "not applicable" normally is associated with the non-use.

The survey includes an initial header, which presents the duration of the investigation, and some information to fill by the user, like the company and its address, date of the survey and some characteristics that define the user (sex, age, job title, for how long has work in the building).

3. Case of Study

The validation of the surveys of users satisfaction assessment is made in a company named SISCOG - COGNITIVE SYSTEMS SA. SISCOG is a software company that provides decision support systems for resource planning and management in transportation companies, with special experience in the field of railways. Founded in 1986 by Professor Ernesto Morgado and by Professor João Pavão Martins, SISCOG uses a combination of Artificial Intelligence and Operational Research technologies, resulting in state-of-the-art optimization software (SISCOG, 2002). The company human resources consists of 107 employees and is located in Campo Grande (Portugal) at number 378, occupying an entire floor and a half floor of a four-story building, being headquartered there since the end of 2000.

After accomplish the surveys to the users of the building, it was felt the need to investigate specific aspects of the surveys, in order to understand some physical characteristics of the building, as well as some routines of the users of the building. To this end, it was solicited some of photographs of the office, a general layout of the space and it was prepared a set of questions to perform one of the users building (space organization – open space, material of the floor, how is the system of ventilation etc.), to improve the understanding of some results of the surveys.

4.1 Characterization of the users

The surveys were performed from 6 to 12 of February 2014, by email, and sent by the management to the employees of the building. It was possible to obtain 77 responses, assuring that the respondents were users of the building, including the company's employees that perform different functions.

The range of ages obtained from the responses *Age* is between 24 and 56, in which 37% of replies were female and 63% were male.

Some of the employee positions presented in the survey responses - position held - are as follows (associated to the respective percentage obtained in individual results) (in alphabetical order):

- Assistant marketing (1%);
- Administrator (1%);
- Business developer (1%);
- Director (includes quality manager and human resources) (7%);
- Management (1%);
- Management of software maintenance (4%);
- Management of the portfolio (3%);
- Programmer analyst (34%);
- Team Leader (8%);
- Technical Writer (1%);
- Senior secretary (1%);
- Software Engineer (16%);
- Software tester (14%);

8% didn't respond to this question.

In the question *for how long do you work on the building*, the answers ranged from 3 days to 13 years. The second value corresponds to the company establishment in the current location.

It's important to notice that the answers of the users, who are in the building for less than 1 year, condition some responses, such as the evaluation of the temperature inside the building in different seasons - summer and winter - they can't answer both, because they didn't work at the building long enough.

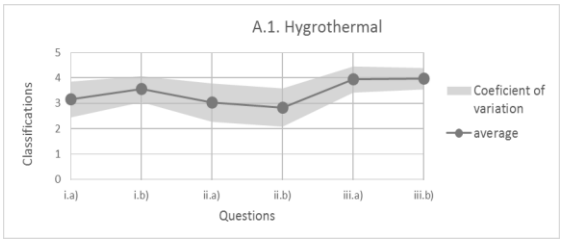
In the results obtained in the question *how long have you worked in the building*, more than half of the users (65% of the inquired) responded that they have been working for over a year in the building; 21% of the inquired responded that they have worked there only a year or less; the rest of the results - 14% - correspond to the users who have not responded to this category or responded inadequately.

4.2 Discussion of results

In this study, we obtained a sample of 77 surveys, having proceeded to a simple statistical analysis to evaluate the results.

- **Hygrothermal Comfort**

Analyzing the results presented on Figure 3 it is possible to observe that the matter that refers to the ability to control individual devices, heating and cooling, have the worst ratings average obtained (ii.a) x=3,0; ii.b) x = 2,8), as well as a higher coefficient of variation (ii.a) cv=38%; ii.b) cv= 38%), that reflects poor unanimity of the answers given by the users. The answers that obtained higher average results refer the humidity (iii.a) x=3,9; iii.b) x=4,0) , especially in winter, where it is observed a low coefficient of variation (iii.a) cv= 26%; iii.b) cv= 21%). The issue of humidity also got several answers *don't know / don't apply*. The fact that users answered this type of response is positive, because if there were humidity issues they would have assigned a rating. The question concerning the comfort temperature - summer and winter - had satisfactory ratings (i.a) x = 3,2 and i.b) x =3,6), although this factor may be unrepresentative because it is known that the building is composed of different rooms, subjected to different temperatures, which may reflect some very hot rooms and other very cold rooms. This should be noted in item above (i.a) summer) that presents a coefficient of variation of 35%.

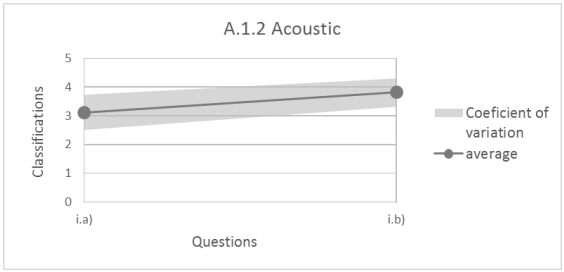


Note: 1 - Very bad (inadequate); 2 - Bad; 3 - Acceptable 4 - Good; 5 - Very Good; ia) - "How do you rate the ambient temperature?" - summer; ib) - "How do you rate the ambient temperature?" - Winter; ii.a) - "How do you rate the ability to control individual equipment?" - Heating; ii.b) - "How do you rate the ability to control individual equipment?" - Cooling; iii.a) - "How do you rate the humidity?" - summer; iii.b) - "How do you rate the humidity?" - winter.

Figure 3 – Average ratings of Hygrothermal

- **Acoustic Comfort**

The results of acoustic theme on the a.i) inside and i.b) outside, can be observed in Figure 4. The average of responses in i.a) was attributed to the acceptable classification 3,1. However it can also be observed some dispersion in the results (high coefficient of variation - i i.a) cv = 31%) , obtained by different classifications, which may correspond to a deficiency of sound insulation in just some rooms, a fact explained by the type of spatial organization that the layout offers. The i.b) outside acoustic shows an approximate average result of 4 (*good*). In the analysis results, we can conclude that the noise from the outside produces satisfactory results.



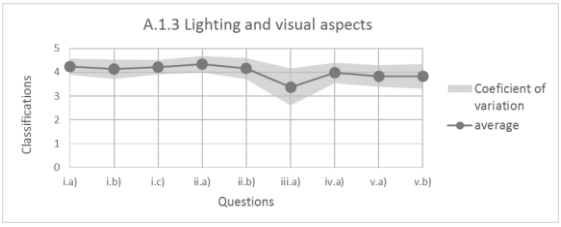
Note: 1 - Very bad (inadequate); 2 - Bad; 3 - Acceptable 4 - Good; 5 - Very Good; .ia) - "How do you rate the sound insulation?" - inside provenance; i.b) - "How do you rate the sound insulation?" – Outside provenance.

Figure 4 – Average ratings of Acoustic

- **Lighting and visual aspects**

The general results displayed in Figure 5 allow to analyze an average level of ratings of approximately 4 (*good*),

responses except in question iii.a), which refers to the ability to control individual devices (iii.a) x= 3,4). This question got a lower rating than the others, and shows a visible dispersion of results (iii.a) cv= 39%), as we know (and as may be seen in Figure 6) there is no individual lighting, only general, in the office rooms, and this fact can justify this dispersion. It is also worth mentioning the iv.a) having an average rating of 4,0 (*good*), it is known that two of the windows in the office are directed to the Garden of Campo Grande and the others to the surrounding buildings (including Foundation City of Lisbon, which presents a remarkable aesthetic and arquitectural landmark), so it is considered that these may be the main factors to get this rating. Observing a low coefficient of variation (iv.a) cv = 21%), it can be considered that there is a consensus in the responses obtained.



Note: 1 - Very bad (inadequate); 2 - Bad; 3 - Acceptable 4 - Good; 5 - Very Good; i.a) - "How do you rate the artificial lighting?" - General; i.b) - "How do you rate the artificial lighting?" - Individual; i.c) - "How do you rate the artificial lighting?" - Color; ii.a) - "How do you rate the daylight?" - General; ii.b) - "How do you rate the daylight?" - Single iii.a) "How do you rate the ability to control individual equipment?" - individual lighting; iv.a) "How do you rate the visual factor?" - Indoor / Outdoor; v.a) "How do you rate the appearance of space (aesthetics)?" - Common spaces; v.b) "How do you rate the appearance of space (aesthetics)?" - individual spaces.

Figure 5 – Average ratings of Lighting and visual aspects

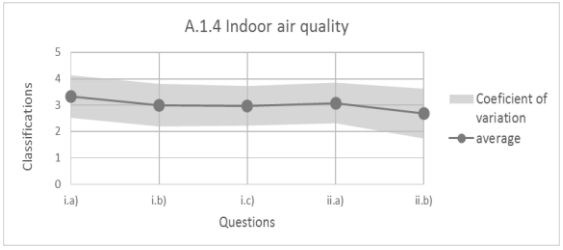
Figure 6 – Work space

- **Indoor air quality**

To evaluate the indoor air quality in terms of i.a) odors, i.b) natural ventilation and i.c) air-conditioning by observing the Figure 7, it's possible to check that the results are acceptable. However, it is also possible to observe not a lot of consensus in the responses of both issues, which reflects on high coefficients of variation. This can be justified by the existence of different rooms in the office, where each user could be exposed to different conditions. It's noted that i.b) the allocation of natural ventilation refers to some answers of *don't know/don't apply*. It appears that this type of response is due to the fact that only some rooms don't have natural ventilation.

In the analysis of the question, concerning the control of ventilation in ii.a) rooms and ii.b) toilets, is known that there is no individual control of mechanical ventilation for all rooms and toilets. In the case of the rooms, some have windows, therefore including natural ventilation. Unlike the others rooms and the toilets don't have any control ventilation, mechanical or natural, as there are no windows in these spaces. Considering the control of natural ventilation in the rooms, it was assumed that the users agreed to that, when answering to the question when applicable, so it was obtained an average rating of 3,1 (*acceptable*).

Regarding the lack of ventilation in toilets, most of the responses focused on *don't know/don't apply*, with an average of assigned ratings of 2,7 (*bad*).



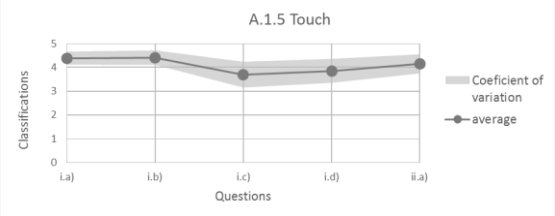
Note: 1 - Very bad (inadequate); 2 - Bad; 3 - Acceptable 4 - Good; 5 - Very Good; i.a) - "How do you rate the quality of indoor air" - odors; i.b) - "How do you rate the quality of indoor air" - natural ventilation; i.c) - "How do you rate the quality of indoor air?" – Air-conditioning; ii.a) - "How do you rate the individual control of ventilation?" – Rooms ; ii.b) "How do you rate the individual control of ventilation?" - Toilets.

Figure 7 - Average ratings of Indoor air quality

- **Touch**

By observing the results in Figure 8 about material properties i.a) temperature, i.b) harshness / roughness, i.c) flexibility / mobility equipment, i.d) the dimension of furniture, is possible to see in the responses obtained good ratings. The lower limit of ratings presented by this

set of questions corresponds to i.c) flexibility / mobility, having an average rating of 3,7 and the upper limit of ratings corresponding to i.a) temperature and i.b) harshness / roughness, with average rating of 4,4. It can be assumed that users are satisfied with the existing working equipment. The ii.a) Static electricity is not always noticeable and this is why there is large concentrations of responses of don't *know/don't apply*. It is considered, in this case, that when you get this type of response, it should be evaluated as a good result, because if it were noticeable to users, they would tend to ascribe a negative rating for being a derogatory sense related to discomfort. However, the average rating obtained was 4,1.

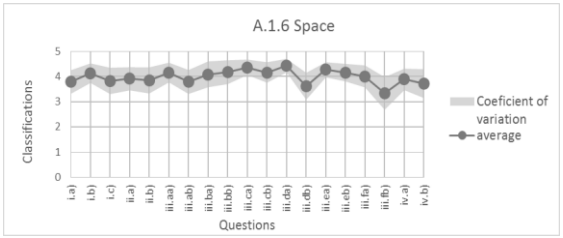


Note: 1 - Very bad (inadequate); 2 - Bad; 3 - Acceptable 4 - Good; 5 - Very Good; i.a) - "How do you rate the features of the work elements (individual) existing" - Temperature; i.b) - "How do you rate the features of the work elements (individual) exist?" - harshness / roughness; i.c) - "How do you rate the features of the work elements (individual) exist?" - Flexibility / mobility equipment; i.d) "How do you rate the features of the work elements (individual) exist?" - Size of furniture; ii.a) - "How do you rate the existing static electricity?" – Inside of the building.

Figure 8 - Average ratings of Touch

- **Space**

It's possible to observe in Figure 9 that the responses obtained show similar average ratings, except on the satisfaction of using i.db) lifts and i.fb) eating/canteen, presenting average somewhat lower when compared to the others (i.db) x = 3,6 and i.fb) x = 3,3). It should be noted the aspect that provides the best results, referred to the i.da) location of the elevators, with an average rating of 4 (*good*) and a low coefficient of variation (i.da) cv = 13%). It is possible to consider that in general, users are satisfied with this aspect. The iv) physical arrangement of the elements also got acceptable ratings, both with an average of 3,4.



Note: 1 - Very bad (inadequate); 2 - Bad; 3 - Acceptable 4 - Good; 5 - Very Good; ia) "How to rank the physical layout of the elements that make up the workspaces?" - Partitioning of the office/rooms; ib) "How to rank the physical layout of the elements that make up the workspaces?" - Circulation; ii.b) "How rating the physical layout of the elements that make up the workspaces" - Signaling; ii.a) "How do you rate the size of these spaces?" - general; ii.b) "How do you rate the size of these spaces?" - indivudal; iii.aa) "How do you rate the location (toilets); iii. b) "How would you rate your satisfaction in use (toilets)?"; iii.ba) "How do you rate the location (reception)?"; iii.bb) "How do you rate satisfaction in use (reception)?"; iii.ca) "How do you rate location (meeting room)?" iii.cb) "How do you rate satisfaction in use (meeting room)"; iii.da) "How do you rate location (elevators)?"; iii.db) "How do you rate satisfaction in use (elevators)?"; iii.ea) "How do you rate location (stairs)?"; iii.eb) "How do you rate satisfaction in use (stairs)?"; iii.fa) "How do you rate location (canteen / eating)?"; iii.fb) "How do you rate satisfaction in use (canteen / eating)?"; iv.a) "How do you rate the physical layout of the elements that make up the workspaces?" - Common; IV.B) "How do you rate the physical layout of the elements that make up the workspaces?" - Solo.

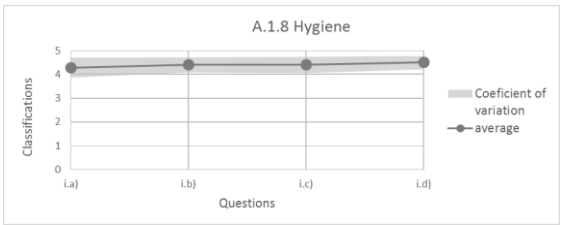
Figure 9 - Average ratings of Space

- **Dynamic**

Just like the classification of static electricity, the factor of vibration may also be an aspect that has some tendency for the response *don't know / don't apply* when it's not detected, because when it is felt is considered negative. Nevertheless, and contrary to what was found in matter related to static electricity, few responses were assigned to *don't know/don't apply*. Thus, it can be assumed that the question is well understood by the users. The average rating obtained was 4,2, so it can be concluded that there were no significant vibrations in the building.

- **Hygiene**

Looking at Figure 11 to the values of the average obtained, in the different questions, and their coefficient of variation, it's possible to observe that the results are very similar. This was the group that got the best ratings of the study, reaching an average rating between 4,3 and 4,5.

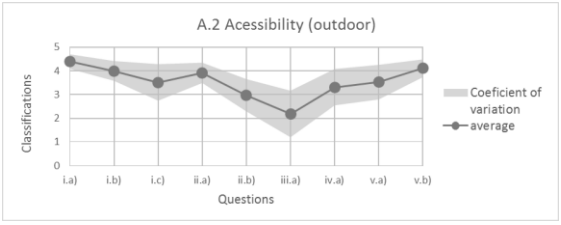


Note: 1 - Very bad (inadequate); 2 - Bad; 3 - Acceptable 4 - Good; 5 - Very Good; ia) "How do you rate the quality of the water?" - Flavor; ib) "How do you rate the quality of the water?" - Odor; icas) "How do you rate the quality of the water?" - Temperature; ic) "How do you rate the quality of the water?" - Color

Figure 10 - Average ratings of Hygiene

- **Accessibility**

From Figure 11 it's possible to deduce some flickering in the rating obtained. The answer that got the worse classification is referred to iii.a) quality outdoor parking (x = 2,2, *bad*), where it is evident the users dissatisfaction. It should be noted that the questions that refer the access by i.c) individual transport (cv = 39%), the quality of iii.a) outdoor parking (cv = 50%) and iii.b) indoor paking (cv = 38%), and the accessibility to the interior of the building by iv.a) ramps (cv = 37%), are associated with a considerable coefficient of variation, and the parking outside got the highest in any inquiry applied.

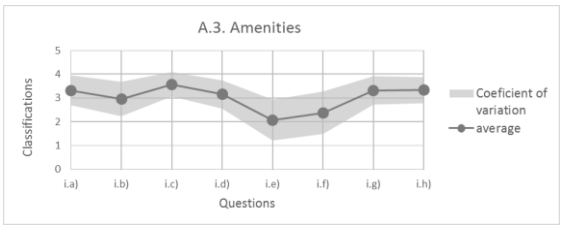


Note: 1 - Very bad (inadequate); 2 - Bad; 3 - Acceptable 4 - Good; 5 - Very Good; i.a) "How do you rate the accessibility of the building?" - public transportation; i.b) "How do you rate the accessibility of the building?" - Bicycle; i.c) "How do you rate the accessibility of the building?" - Individual Transportation; ii.a) "How do you rate security in circulation?" - Crosswalk; ii.b) "How do you rate security in circulation?"-Bike; iii.a) "How do you rate the quality of parking?" - Outside; iii.b) "How do you rate the quality of parking?" - Inside; iv.a) "How do you rate the accessibility to the interior of the building?" - Ramps; iv.bb) "How do you rate the accessibility to the interior of the building?" - Stairs.

Figure 11 - Average ratings of Accessibility

- **Amenities**

From Figure 12 it is possible to conclude the users dissatisfaction, regarding some specific amenities. It is considered that some of the aspects got lower ratings, not because of lack but for unawareness of their existence. The amenities having worst outcomes, on average ratings and in higher coefficient of variation, are those concerning points i) stores (x = 2,1) and if) supermarkets (x = 2,4), with a coefficient of variation of (i.e) stores - cv = 43% and i.f) supermarkets - cv = 45%)). This was the group, in the entire of the investigation that got the lowest average ratings.

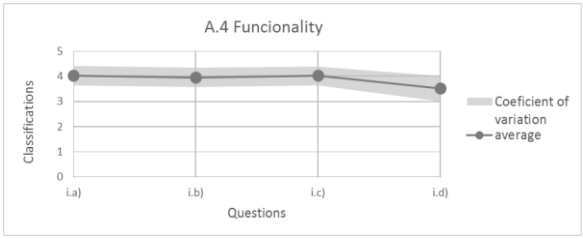


Note: 1 - Very bad (inadequate); 2 - Bad; 3 - Acceptable 4 - Good; 5 - Very Good; i.a) "How do you rate the existence of amenities?" - Cafes; i.b) "How do you rate the existence of amenities?" - Restaurants; i.c) "How do you rate the existence of amenities?" - Schools; i.d) "How do you rate the existence of amenities?" - Nurseries; i.e) "How do you rate the existence of amenities?" - Shops; i.f) "How do you rate the existence of amenities?" - Supermarkets; i.g) "How do you rate the existence of amenities?" - Gyms; i.h) "How do you rate the existence of amenities?" - Pharmacies.

Figure 12 - Average ratings of Amenities

- **Functionality**

The functionality of the building elements got satisfactory responses; the ratings are very close, as it could be observable in Figure 13. Only at the last topic, which refers to the i.d) mechanical equipment of the building (printers) (x= 3,5), there was a lower average rating, but never the less still acceptable.

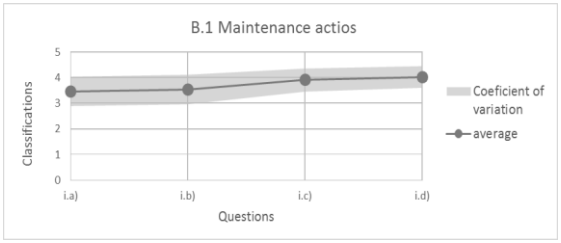


Note: 1 - Very bad (inadequate); 2 - Bad; 3 - Acceptable 4 - Good; 5 - Very Good; i.a) "How do you rate the functionality?" - Doors; i.b) "How do you rate the functionality?" - Windows; i.c) "How do you rate the functionality?" - general mechanical equipment (elevators); i.d) "How do you rate the functionality?" - Mechanical equipment of the building (printers).

Figure 13 - Average ratings of Functionality

- **Maintenance actions**

In Figure 14 it is possible to see that the first question rating is lower when compared to the others results (i.a) Stop time of operation of elements in maintenance, x=3,5) and it can be characterized by a higher coefficient of variation and lower average ratings. Although it is possible to consider these results as acceptable. The last two paragraphs have more satisfactory ratings (i.c) State (deterioration) of the elements of use x= 3,9, i.d) - State (deterioration) of the structural elements x=4,0), being considered as good results.



Note: 1 - Very bad (inadequate); 2 - Bad; 3 - Acceptable 4 - Good; 5 - Very Good; ia) "How do you rate the maintenance actions?" - Stop time of operation of elements in maintenance; ib) "How do you rate the maintenance actions?" - Quality of maintenance services; ic) "How do you rate the maintenance actions?" - State (deterioration) of the elements of use; id) "How do you rate the maintenance actions?" - State (deterioration) of the structural elements.

Figure 14 - Average ratings of Maintance actions

- **Adaptability**

Globally, this topic can be considered as an aspect that summarizes the general characteristics of the entire building. This question got an average rating of 3,9, which that is considered as a good evaluation. Thus, it can be assumed that the overall result is satisfactory.

4. Conclusions

In this work, it may be concluded that the organization of the indicators carrying out the performance appraisals should be done in very specific groups, and when required, through an iterative process. The assessment by the indicators should understand which measurement technique is most adjusted, considering their limitations and, if it is possible, mobilizing the means in its application. The selected measurement technique is not always easy to apply, deserving the indicators evaluation further study and a more comprehensive knowledge, especially when it comes to laboratory work and applying formulas, among others.

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