PLEA *2017* EDINBURGH
Design to Thrive

How do you live? Evaluation of environmental quality of housing in Uberlândia (Brazil)

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Abstract: This paper presents part of the research that aims to develop a post-occupancy evaluation (POE) interactive system over digital media to identify the quality of the houses under investigation. The feasibility of this interactive system is been tested in case studies in the city of Uberlândia (Brazil) and may fundament its future replication in other cities. This paper focuses on the theoretical foundation of the research as well as on its environmental approach, considering the strategies used to verify the environmental quality of housing within the proposed evaluation system. Besides energy efficiency and environmental performance of housing, this research was interested to identify the behaviour of dwellers regarding the use of different natural resources, analysing their habits and actions. Preliminary results indicate that the use of technologies and digital resources can minimize some of the frequent problems that occur in traditional POE studies, as they increase the efficiency of evaluation results, reduce the execution time and the costs of researches, and increase the interest of the questionnaire respondents, especially concerning issues related to the sustainability of the built environment.

Keywords: Post-occupancy evaluation; Technology innovation; Digital interfaces; Environmental quality; Sustainability.

Introduction

With a large array of possibilities in research, the theme of “housing” has been studied with varying approaches and broken down into extracts. Even though the perspective of each analysis varies, they conjoin on the understanding that “living” represents a fundamental act in human existence. The psychic importance of the house in the constitution of the individual is emphasized by Penzim (2007), indicating that the house brings the possibility of synthesis of life for “man”, setting itself as a shelter for different human activities.

Apart from the condition of this protective space as a shelter, housing also represents a space for private life, permitting the interdependent establishment of relationships and, at the same time, respect for intimacy (Kunze; Conciani, 2004). However, while living spaces are individual, they present a collective dimension: each member of the family occupies a single enclosure and, in addition to this, the people of this family interact and socialize with the neighbourhood, the district and the city (Araújo, 2005). Because of this, the analysis of the house, shelter of “living”, should always be related to the investigation on the physical territory and the environment in which it is situated.

To ascertain “How do you live?”, in the scope of the research presented here, is seeking to learn the multiple meanings of “to live” within the following dimensions: physical, behavioural and urban insertion. Considering the importance of living to the human being, the necessity of knowing how the residents of our cities are being sheltered is justified. In other words, it is important to evaluate the housing quality.

In this context, observe that Brazilian cities receive hundreds of housing units per year, implemented by public and private agents, that contradict basic housing principles: aspects of functionality, spaciousness and privacy are generally attended with minimum attention - as can be proved in studies of Post-Occupancy Evaluation (Amore; Shimbo; Rufino, 2015; Villa; Saramago; Garcia, 2015). This situation notably intensified in the first decade of the 21st century, when there was a significant increase in the access to credit, pressing the demand for different typologies of housing units around the country.

With this in mind, Post-Occupancy Evaluation (POE) is a fundamental tool in the evaluation of the quality in Brazilian housing production. The relevance of POE for the attainment of the level of quality in the architecture project is already consolidated enough for use in other studies in the field of civil construction (Voordt; Wegen, 2013; Villa; Ornstein, 2013). The role of management of the project process, in which POE is inserted, from the service received to the quality of the built spaces, notably in housing, were also amply researched (Mallory-Hill, Preiser, Watson, 2012; Kowaltowski et al., 2013).

On the other hand, apart from the effort to found the quality of housing, observe that many studies are limited, in as such that the works often focalize certain aspects that configure the quality of housing. This is the case in the researches that focus on the systems related to environmental comfort and the energy efficiency of the housing units, of which, initially, centered on defining parameters of performance of these systems, whereas more recent studies have shown the necessity of revising the parameters of evaluation proposed initially.

In Holland, for example, it was concluded that more efficient technology, in general, reduce the price of energy services, motivating a change in the behaviour of users, increasing energy consumption (Visscher; Werf; Voordt, 2013). In the United Kingdom, according to Stevenson (2013), the problem centers on the absence of more concise studies on the usability of low carbon technologies. Therefore, when these technologies do not attend the intended purpose - presenting incorrect installation and operation - a potential negative reaction is generated towards their adoption on the part of the residents. Thus, it has been noted that environmental measures should be related to the daily life of the residents and their expectations (Martincigh et al., 2016), even in the cases of high performance buildings (Yudelson, 2016).

Thus, this research reinforces the need to identify the role of the residents in the reduction of environmental impacts, by analyzing their habits and actions. It also aims to contribute to the current discussion on the way to live in an opportune moment, given the quantity of housing enterprises launched daily in Brazil. Therefore it has become necessary to consider the quality of such production, certifying how they meet the following points: (i) the technical specifications of used construction materials and systems to guarantee the comfort of residential units; (ii) the ways of living of different family, social and cultural profiles, which influencing their actions on the environment; and (iii) the urban impacts generated by the implantation of the houses.

Objectives of the research

This research aims at developing a POE interactive system through digital media that permits to identify the quality of the housing. The feasibility of this interactive system has been tested by case studies in the city of Uberlândia (Brazil) and may fundament its future replication in other cities. The methodology of POE through digital media focuses on the functional, behavioural and environmental aspects of housing and is organized in a stage that begins with the residents' personal details and goes up to the evaluation of the residential unit itself. This work focuses specifically on the environmental quality of the proposed evaluation system.

Methodology of the research

Methodologically, the questionnaire is structured in the: (i) bibliographical research (internet and libraries) about typologies, aspects and evaluation of living with the aim to establish the current state of the art of the proposed thematic; (ii) categorization and definition of the main attributes approached in the evaluation; (iii) identification of the limits and extracts of the evaluation system to be developed from the definitions above, characterizing and defining their parts, tools, workings and also objectives; (iv) development of working prototypes of the interactive POE system through digital media (PCs); (v) application of tests for the tools of the system using functional prototypes on the population of Uberlândia; (vi) development of the interactive POE system through digital media (internet, e-tablets and smartphones); (vii) application of definitive tests of the interactive POE system through digital media on different types of housing in the city of Uberlândia, with the aim of its future replication throughout national territory; and (viii) availability of the interactive POE system through digital media to the community.

With the specific objective of evaluating the environmental housing quality and to support the development of the evaluation system through digital media, methodologically, the questionnaire was structured by: (i) the discrimination of the evaluation attributes of the housing in view of environmental quality; (ii) the elaboration of the questions to be inserted into the proposed evaluation system; (iii) the creation of educational feedback on the questions for the users; (iv) support for the development of the evaluation system; (v) testing the evaluation system in case studies in Uberlândia; and (vi) the organization of the database for the environmental quality for living.

Thus, the first stage of the research involved the consultation of various sources to identify and characterize the attributes of the housing environmental quality evaluation on different scales (physical, behavioural and urban insertion). With these attributes defined, the questions to be inserted into the evaluation system were elaborated (second stage), therefore identifying the possibility to inform the respondents, throughout the questionnaire, about their behaviour - in other words, to create educational feedback (third stage).

For the fourth stage, the work continues the studies developed in the scope of the group "[MORA] pesquisa em habitação"[1] of the Faculty of Architecture and Urbanism and Design at the Federal University of Uberlândia, focusing exactly on Post-Occupancy Evaluation methodologies and digital interfaces, in particular the DIGITAL POE research, which proposes software and an interface destined for the evaluation of apartment

[1] https://morahabitacao.com

buildings using digital tools (e-tablets, web)[2]. Although, the work presented here has extended the use of the tools developed, in the sense that to elaborate a system that can be employed in different typologies of housing. Therefore, parallel to the definition of the attributes in the evaluation, another team developed the graphic design of the new system, as well as the digital interface. Thus, the fourth stage gave support to the development of the tools for the evaluation system through digital media (e-tablets, web) as in the aspects related to sustainability and the environmental comfort - considering, therefore, the results of the previous stages.

After the development of the interactive system, the next stage of the research consisted of applying it to the users of varied housing typologies in Uberlândia to test its viability. Such an application, being work in progress, can indicate the necessity for adjustments to be made as much in the evaluation tool being developed as in the actual questions being asked. Finally, from the participation of different users in the evaluation of housing quality in Uberlândia, it will be possible to organize a database of different aspects of living, including those which are more specifically related to the environmental quality of the housing (sixth stage). It is intended that the systematization of the results generate informative graphs and schemes.

Results and discussion

To better analyze the results obtained through the research, they were organized into the methodological stages described above: attributes for the evaluation of environmental quality, elaboration of questions and feedback for the POE and the interactive system for the evaluation of housing quality through digital media.

Attributes for the evaluation of environmental quality

Previous researches were used, as a reference, for the determination of the attributes to be used in the evaluation (Villa; Saramago; Garcia, 2015; Villa et al., 2016), which also dealt with the application of POE in housing to verify environmental quality, although in other extracts (apartment buildings or/and social housing). Therefore, considering the works that have been developed previously, the reach of the current investigation has been extended aiming at the contemplation of different housing typologies (horizontal or vertical; in closed gate communities or allotted space).

Furthermore, the analysis scales in the questionnaire focus on: physical (technical and constructional aspects, attesting the environmental quality of the residential units, especially in terms of comfort), behavioural (habits and actions of the users that have an impact on the way they live) and urban insertion (impacts derived from the implantation of housing in the city). It was considered that the environmental approach of the research should be in balance with the analysis of functionality, also present in the general research and responsible for questions relative to the ways of living (uses and activities present in the domestic environment), of the family profiles and the spatial necessities of the residents.

Thus, from the different data collected, the evaluation attributes were categorized into the following aspects: environmental comfort (thermal, lighting and acoustic), water and energy consumption, waste collection and disposal, consumption of organic food, vegetation and urban mobility - which are all better described in the following item.

[2] https://morahabitacao.com/digital-poe-1/

Elaboration of questions and feedback for the POE

With the environmental quality of housing evaluation attributes defined, the questionnaires created were revised in view of the previous questionnaires, mentioned above, with the intention of: improving the existing questions, contemplating different typologies of housing and adding question to better verify the habits of the residents in terms of the reduction of environmental impacts of living. Therefore, tables of possible questions, relating to the attributes of the evaluation, were created.

Table 1. Attributes and aspects evaluated.

Evaluation attributes	Evaluated aspects
Environmental comfort	Natural ventilation Natural lighting Temperature Noise levels
Water	Reasons for saving water (or not) Actions to save water Water saving devices
Electricity	Reasons for saving electricity (or not) Actions to save electricity Solar energy equipment and systems
Waste	Recyclable materials x non-recyclable Collection points of recyclable materials Collection and disposal of: oil / waste of construction / batteries and electronic equipment / expired medicines
Organic food	Organic food consumption Reasons for consuming organic food (or not)
Vegetation	Presence of green areas in the house Reasons for cultivating plants (or not)
Urban mobility	Transport mode used according to distance Reasons for using specific kind of transport mode

In the questionnaire, the evaluation of environmental comfort of the units occurs through the identification of the level of satisfaction of respondents in reference to each room of the housing (physical scale) in terms of: natural ventilation, natural lighting, temperature and noise levels (Table 1). On the elaboration of the database, questions will be cross-referenced with other technical and constructional aspects evaluated (like, for example, the carrying out of refurbishments and improvements aiming at better living conditions and comfort in the rooms).

On the other hand, the block of questions aiming at identifying the level of environmental awareness of the residents divides their habits and actions in terms of: water and energy saving; reasoning for the saving of water and energy; the presence of solar energy (heaters and/or photovoltaic panels); use of water saving devices; the collection and disposal of waste (domestic, recyclable, oil, expired medicines, construction, batteries and electronic equipment); knowledge on collection points; consumption of organic food and justification; interaction with vegetation (presence of green areas on the plots and in the units as well as justification for their presence or absence) and urban mobility (common mode of transport and justification for its use).

With this in mind, the scales of evaluation were merged with one another, together with the general research, since the habits and actions (behavioural scale) relate to the residential unit itself (physical scale) revolves around the city in which unit is inserted (urban scale). To simplify the process of the elaboration of the proposed evaluation system, the

types of responses were also indicated: dichotomic (yes/no), trichotomic (yes/no/don't know), and multiple choice (possibility of more than one answer) and with on a semantic differential scale (on a scale of values). In the last case, a scale of values of 5 points was used to verify the perception of the user (resident) for that attribute under analysis. Moreover, the graphic resources (icons) to be used were indicated to support the team responsible for the design of the interface, as well as how the diversions should be created by the IT team.

Finally, feedback was proposed for the users, aiming to clarify any doubts on the questioned habits, or even triggering changes in the respondents' attitudes along their participation in the evaluation process (Table 2).

Table 2. Example of educational feedback related to the attribute "urban mobility".

FEEDBACK – EVALUATION ATTRIBUTE: "URBAN MOBILITY" – QUESTION "R"
R) What transport mode do you most use in general? - On foot - Bike - Car or motorcycle (FEEDBACK 17, if the interviewer answers this option) - Public transport
FEEDBACK 17: According to several scientists, the emission of gases by private vehicles is a significant cause of global warming. Some strategies can be used to reduce these impacts, such as: creating a network of shared rides to go to work/school; using public transport at least once a week (since this mean of transport carries lots of people, it pollutes less than individual vehicles); and walking or cycling more frequently to places close to home (in this way, it is also possible to reduce air pollution and to improve physical fitness).

Evaluation system for the quality of habitation over digital media

The proposed evaluation system was structured in a way that relates to different attributes, investigated on a clear, intuitive path for the user, reinforcing the user-friendly qualities of the interface and exploring diversion resources which only digital media can offer (Cunningham, Zichermann, 2011; Villa et al., 2016). Therefore, the evaluation was organized - from the functional, behavioural and environmental aspects - into stages which begin with personal details and ending with the evaluation of the housing, divided into system tabs: about you; previous house; current house; condominium; housing unit; sustainable habits (Figure 1). The first tabs contain general data about the resident and housing (current and previous), while from the tab "surroundings" on, the questions evaluate the residential unit and the surroundings in which it finds itself. Thus, apart from the evaluation of environmental comfort of the unit, an exclusive block of questions on the actions of the residents was created in relation to sustainability.

The software for the evaluation system was programmed using the language JAVA while the database uses JAVA/NoSQL technology and the application for tablets and smartphones runs on the programming platform for games, CORONA SDK. The design of the interface sought: (i) the maximize the concentration of possible keywords on a single screen, relative to the attribute being assessed (aiming to optimize time spent to respond to the questionnaire); (ii) to use symbols, colors and animated images to represent these keywords; (iii) to facilitate multimedia resources for the animations; and (iv) to make varying data and information readily available for each attribute to be assessed.

With this in mind, specifically icons were created to better clarify the attributes in the evaluation, relative to the impacts that living has on the environment (Figure 2). In turn, the use of multimedia resources can be exemplified in the evaluation of environmental comfort of the units: for example, indicating temperature, using a thermometer; and using an icon of the sun to evaluate natural lighting. In return, information was made available to

users through the use of feedback. Furthermore, with the objective of making this evaluation system more interactive, a character was created, called “Dr. Clipboard” that aims to accompany the respondent through, practically, the whole assessment, appearing in different forms on the screen. The chromatic palette adopted was used to aid the proposed structure of the questionnaire: the tab “sustainable habits”, for example, being coloured in green, generally seen as representative of the idea of sustainability.

Finally, a first test of the developed system was applied in February of this year aiming to verify its viability and using a sample from 50 answered questionnaires. This application received a welcoming reception of the tool and demonstrated the necessity of some minor adjustments. The results are not the focus of this article.

1. INTERVIEWEE PROFILE	AGE, GENDER, EDUCATIONAL LEVEL, INCOME, DOMESTIC EMPLOYEES, FAMILY MEMBERS
2. PREVIOUS HOUSE	CHARACTERISTICS OF PREVIOUS HOUSE LEVEL OF SATISFACTION WITH PREVIOUS HOUSE
3. SURROUNDINGS OF CURRENT HOUSE	LOCATION OF CURRENT HOUSE LEVEL OF SATISFACTION WITH SURROUNDINGS (PUBLIC FACILITIES AND SPACES)
4. CURRENT HOUSE	CHARACTERISTICS OF CONDOMINIUM (COLLECTIVE FACILITIES AND SPACES)
	EVALUATION OF THE HOUSE AS A WHOLE
	EVALUATING OF ROOMS AND SPACES IN A SPECIFIC WAY DEFINICTION OF THEIR USES (WAY OF LIVE)
5. RELATIONSHIP WITH THE ENVIRONMENT	EVALUATING THE RESIDENT'S BEHAVIOR CONCERNINGS THE ENVIRONMENT AND ITS IMPACT

Figure 1. Tabs of the research and aspects evaluated.

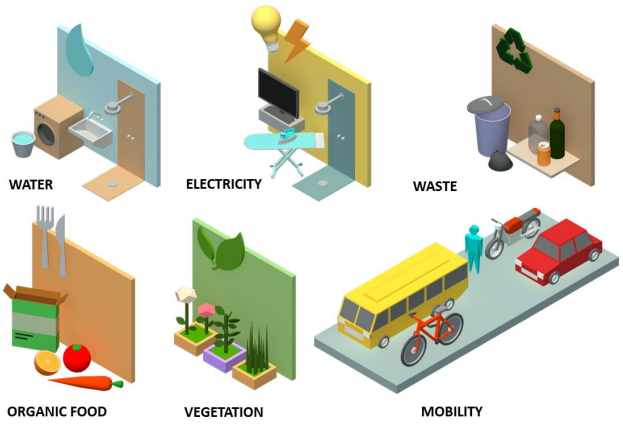

Figure 2. Icons related to sustainable habits.

Conclusions

The interactive system for Post-Occupancy Evaluation of housing quality has the capacity to provide feedback into future projects, focusing on different scales of analysis (house product, behavioural relation of users and their residencies, and the insertion of habitation in urban surroundings). The open plataforms of digital evaluation tools improves technologically in the sense that it brings the user (and their perceptions) closer to the constructed environment (and its attributed meanings) in a more interactive manner. It is

expected that it will be possible to precisely identify the expectations and anxieties of residents - especially in terms of environmental quality of the housing and the level of awareness residents have regarding the impacts of their actions.

Moreover, the establishment of databases on living, based on the statistical and scientific information collected, can amplify the environmental quality of projects in the area. The database is also configured as a means of communication between residents and the productive agents of habitation (public and private), as well as making the evaluation system, developed here, an instrument of information and knowledge for the users themselves on the different aspects related to living, including sociocultural dimensions, as much as of sustainability.

Acknowledgements

We would like to take this opportunity to thank the financial bodies of this project FAPEMIG - the Minas Gerais State Research Foundation, Brazil; CNPq – National Council for technological and scientific development - Brazil; and PROGRAD/UFU – Pro-Rectory of Graduation, Federal University of Uberlândia.

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