Can Darwin show us the way? Improving social housing through an evolutionary design approach

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Abstract

The evolutionary theory of Darwin defends that nature develops through natural selection and in gradual small steps, from specific characteristics in great variety to best-fit specific contexts. This paper builds upon previous research experience on social housing projects in Brazil, to advocate for the gradual introduction of small changes in a standard housing model, as a potential way to improve social housing, through a figurative analogy of the insights offered by Darwin in the field of biology. Cross-analysis of implementation costs and value delivery to end-users forms the basis to validate the proposed evolutionary approach. Darwin further stimulates the study presented here in giving value to detailed observations - in this case, Post Occupancy Evaluation (POE) data - on local social housing. Such data analysis indicates that the present design model needs improvements. Changes should occur in stages, as progressive improvements, through an evolutionary process. Evolutionary change can be tested along the way, avoiding the substitution of an old model with a new, but not yet tried design typology. Value perceived and desired by final users can act as persuasion arguments in the decision making process. The step-by-step approach is useful to convince social housing stakeholders of the true benefit of such improvements and impact on quality of life enhancement. Gradual change is also important for economic reasons, being less costly and technically more viable. Various opportunities for improvement are outlined in this paper, demonstrating that evolutionary, incremental change only needs sporadic larger “mutations”, once simpler elements have been dealt with. As in natural processes, systematic assessments are important after every small evolution, to evaluate if and to which extent improvements were achieved and that they are user- and context-conscious. The discussion on the development of a Darwinian inspired model to improve the design of social housing in the studied context shows that, although mass-produced, this type of architecture can evolve towards more customized, comfortable, sustainable and higher quality homes.

Keywords: Social housing, design improvement, user preferences, value perception, evolutionary design

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1. Introduction

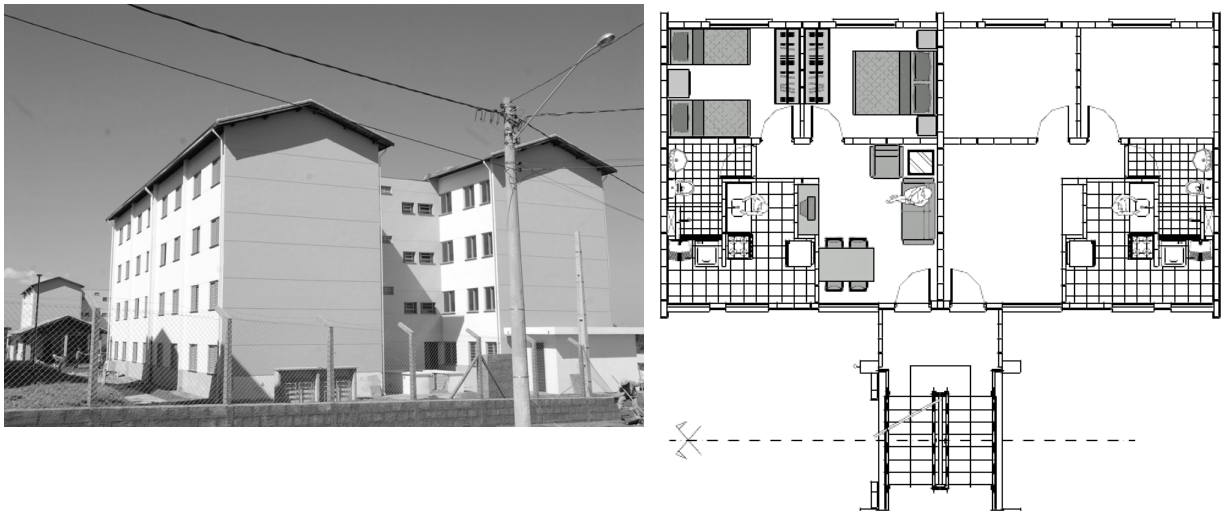
Most of us remember from our high school biology classes something about Darwin and his theory of natural selection, which states that: [the] preservation of favourable variations and the rejection of injurious variations occurs in nature (Darwin, 1859). We also have learned a number of other important things from Darwin, of which few have been applied to social housing or for that matter to architecture or building construction. First and foremost, Darwin shows us the way by advocating the adoption of a more scientific design process, to attain a better fit between desires and delivery in mass housing design. Secondly, the idea of the gradual introduction of changes in a standard housing model is worth to be tested. As shown by Darwin, incremental small mutations can have positive effects in nature. A figurative analogy is herein defended for social housing, using the Brazilian setting as backdrop.

This analogy must be put in its specific context however. The construction industry in general, and housing companies in particular, are conservative and tend to repeat solutions to stay within their comfort zone, being thus adverse to change. Cost is also a major barrier for considering radical modification. Finally, a move towards a new design model should only happen after a thorough multidisciplinary analysis of new proposals has occurred, to allow systematic learning, with an identification of the elements that were successful and those that were not, to avoid the repetition of mistakes in future developments.

2. Social housing in the local context

The housing deficit in Brazil was estimated at 5.6 million homes in 2008, mainly in urban areas. To tackle such enormous figures, many Federal and State programs have been implemented, with massive investments since 2007 to improve housing and urban conditions, including basic sanitation, street pavements and investments in transportation. Design models of social housing have changed little over the last twenty to thirty years in Brazil, and projects developed by the State of São Paulo housing authority - *CDHU* - are used here as the main scenario for pointing out opportunities for improvement. CDHU is the largest producer of social housing since 1986 in the State of São Paulo. Priorities and policies of CDHU are to attend, through subsidies, to the housing needs of low-income level families state-wide. Analogous design principles for similar population strata are adopted, independently of location or size of housing projects.

Many developments are located in smaller cities and thus not especially affected by large urban conglomeration problems, as found in the city of São Paulo, the largest metropolitan area in Brazil. The projects are usually located at the urban fringes, where land value is lower than in consolidated centres. The prime objective is the provision of a large number of housing units, both as detached single-family houses and walk-up apartments blocks. Apartment blocks are primarily H-shaped, with up to 5 walk-up storeys (Figure 1a). A typical floor plan for the residential unit, of some 35 m^2, is shown in Figure 1b. This model is based on providing a minimum culturally accepted set of spaces to families, with two bedrooms, a small living room, kitchen, bathroom and laundry service area. The H-shape allows for cross-ventilation in all apartments, which is an important aspect, given the local tropical climate.



(a) **(b)**

Figure 1: (a) Example of walk-up apartment blocks with surrounding lot fence and small community centre in the background; (b) Sample floor plan of two housing units in a walk-up apartment block.

Minimum standards are applied in relation to indoor space dimensions and construction quality, mainly to attain affordability. The peripheries of such projects will quickly cater to the new population with small shops, bars and everyday services offered in makeshift constructions or adaptations of houses in neighbouring districts. Average monthly income of the population living in typical CDHU projects ranges from one to four minimum wages (around US$300,00 to US$1200,00, in November 2012). Unemployment can be high among such residents, living of informal work and government assistance programs.

Although the projects produced by CDHU can be criticized in relation to the housing quality they offer to end-users, this company has made efforts to improve its standards within the affordability constraints, typical to this context. Construction quality has been the focus of the company's QUALIHAB program, created in 1997. Despite its merits, this plan has not influenced the design model itself. Due to the fact that user satisfaction rates in social housing in Brazil are generally high, changes to the existing model are very slow and not substantial in their impact on housing quality (Kowaltowski et al., 2006). Approval rates of low income families are however not the best indicators of housing quality, since users may have lived in slums or risk areas, paid high rents for poor quality housing or were crammed into borrowed spaces. As legal home ownership status is granted, any degree of housing improvement will be invariably highly rated (Kowaltowski et al., 2006), regardless of its effectiveness. Under these circumstances, little pressure is put on the social housing agents (politicians, housing authorities and construction companies) to invest in new housing designs and to introduce changes to improve social housing for end-users and for urban design quality as a whole.

Literature on housing of the last forty years has criticized design models similar to those of CDHU and shown that retrofit remediation policies are implemented, though with limited success, and that new designs are necessary to avoid repetition of errors and to stimulate

the introduction of incremental improvements. Most studies on progressive improvements of housing in developing countries focus on urban infrastructure. They question the application across the board of global standards, affecting costs and therefore affordability of homes (Choguill, 2007; Ferguson & Navarrete, 2003). Many studies, especially European ones, touch on improvements of the design model as a whole (CABE, 2009_a, 2009_b). In recent years, the literature on building quality assessments has discussed complementary studies to the usual evaluation of satisfaction rates as part of Post-Occupancy Evaluations (POE). The assessment of values that families attach to elements of the home are seen as an important contribution to understand end-user needs, preferences and views related to the built environment (Spencer & Winch, 2002; Benedikt, 2008; Preiser & Vischer, 2005). A study on housing preferences in the UK (CABE, 2009_b) indicated that aspects such as location with good schools and a safe neighbourhood are important, but also external appearance, low maintenance, good quality construction, a private large garden and garage are considered important features of a house or flat. Inside the home, the size and number of rooms and light and ventilated spaces count as positive aspects. The study also showed that architectural style refers to traditional values, although data from e.g. BedZED in the UK, indicate that when a design is well thought through, users will appreciate contemporary aesthetics as well.

3. Social housing design processes

The phases of analysis, synthesis and evaluation were introduced into the field of design when, after the Second World War, designers sought to enter the scientific world, to diminish subjectivity in design, to apply scientific knowledge more effectively and use information technology productively. The methods brought forward by Jones in 1970 were organized according to input (what designers know) and output (what designers want to know) and included a variety of methods still important today. To increase design quality and productivity stakes have been put on design methods in the last fifty years, especially in architecture. The goal in developing design methods was to improve the process and the product outcome. Importance was given to adding structure to the decision-making activity in design. The argument was that, after all, most disciplines depend on tools, techniques, and protocols of good practice, so design and in particular, architectural design should have the same. Figure 2 shows a model of a recommended design process, based on a learning loop, with several analytical and evaluation stages. Figure 3 expands this model to become an integrated process, indicating the specific contributing agents in such a process.

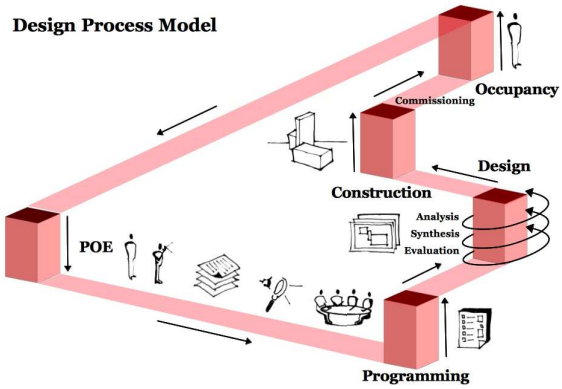


Figure 2. Recommended design process, based on a multi-stage learning loop.

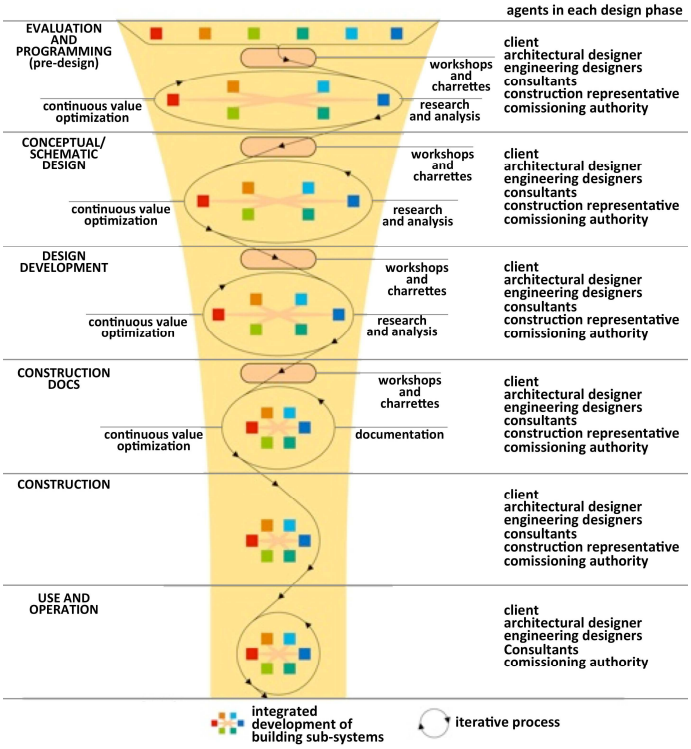


Figure 3. Integrated design process (Figueiredo, 2009)

Many studies have been conducted since the 1960´s, resulting in important contributions to the understanding of the design process. In 1984 Nigel Cross established a division of subjects in design methods and identified each area's principal exponents. Thus, control over the process is the goal of studies by Christopher Jones and Bruce Archer. The structure of design problems - considered as wicked - has been discussed by Peter Levin, Barry Poyner, Melvin Webber and Horst Rittel. Wickedness consists in the continuous redefinition of the problem during the period of its resolution and the impossibility of testing the validity of solutions. The cognitive aspects of design are studied by Ömer Akin, Bryan Lawson, Jane Darke, John Thomas and John Caroll; while the philosophy of design methods is further investigated by Geoffrey Broadbent (1973) and Nigel Cross (1984).

Most studies on the design process in architecture show that it does not follow rigid rules. Designers do not apply universal methods and rarely externalize their thought process. Research in design methods considers the creative process complex, solving what are termed wicked or ill-structured problems (Rittel & Webber, 1973). Thus, design problems are only loosely formulated, at times through a detailed brief or architectural program. A rigid systems view of design cannot therefore be defended, even in the face of losing credibility regarding the design profession, since rationality in design may forget to embrace important concepts such as value judgment, context and uniqueness. In design, as a form of problem solving, reasoning proceeds from objective and functional assessment to means or (product) decisions, but does not follow a formal scientific process in which, by deduction, one reaches a logical result from posed premises. To improve this process, creative methods are seen as important to stimulate original and quality solutions. Jones (1970) already emphasized the importance of methods that aid in the search for ideas in design processes. In such early texts Brainstorming, Morphological Charts and Removing Mental Blocks are mentioned as appropriate tools.

The overview of studies on the process, its principles and methods, as well as the philosophies and theories on architecture and its creative process, shows that design studies are essentially interdisciplinary. From this, an understanding of the rich data coming from the design methods movement is created, which continues to have repercussions in diverse areas, contributing to the development of specific research domains that support professional activities. POE/Building Performance Assessment has gained importance and design quality evaluation methods are being developed, including the ever more present sustainability certifications. Attention to the pre-design phase, or the development of a detailed design brief, has increased in professional activities. Computational support tools, such as Computer Aided Design (CAD), rapid prototyping and applications of artificial intelligence have sprung from the design method movement to enrich and facilitate the design process.

The local social housing process has few of these items. Housing authorities such as CDHU are connected to the local political system and serve the government’s interests. In this context, changes are slow to take effect, since the indicator valued the most by implementing agents is the number of homes distributed during a political term. Costs are reduced to maximise the number of residential units produced and allocated to low-income families. Thus, change in design is avoided since the model in use has already been tried and tested at the lowest costs. There is no feedback loop and the cost of a new design phase is avoided, since old known models are perpetuated and evaluation is superficial. Moments of reflection during the design process are important however, for several reasons. Consultants of various specializations in design and construction can be added to bring their expertise to solving specific problems. Reflection also creates opportunities for more routine corrections, avoiding later retrofits. A reference model for an evolutionary design process for social housing can be constructed as shown in Figure 5. The boxes indicate gradual improvement through step-by-step changes in design or retrofit interventions, which can be assessed and applied until the model is no longer able to incorporate small incremental changes and a larger “mutation” (i.e. design model substitution) is needed, as informed by analysis and feedback loops. End users – or their proxy, from a potential users pool - should

be included in the reflective stages to voice real demands and increase understanding in relation to design solutions, adopted to increase constructive criticism and eventually satisfaction rates. In this way, giving importance to local specifics and opinions, as well as facts, can be part of an improved social housing design and construction process.

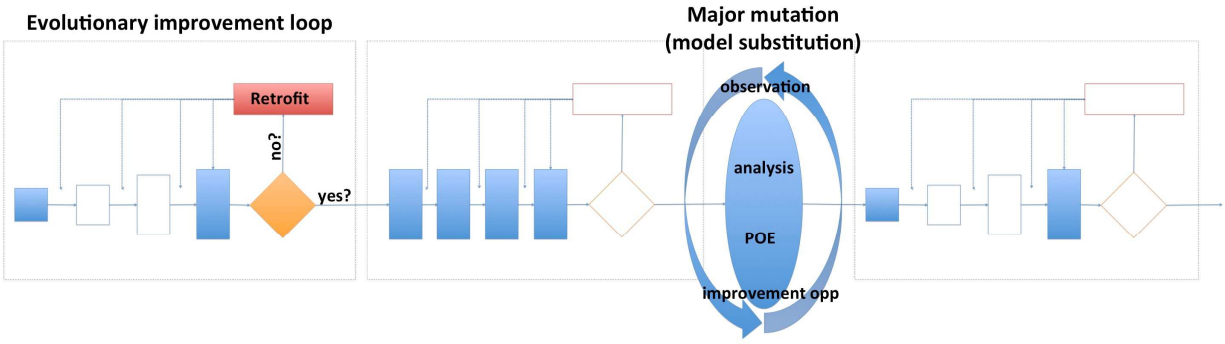


Figure 5. Analogy model for evolutionary change in social housing design

4. Methodology and research approach

The present argumentation advocates for the gradual introduction of small changes in a standard housing model. The paper deploys reasoned previous research experiences by the authors as arguments to promote a figurative analogy between Darwin's evolutionary, natural selection understanding and potential improvements in social housing delivery processes. Kowaltowski & Granja (2011) conducted a study in which end-users of four multifamily social housing projects, based on five storey walk-up apartment blocks, were asked to identify the most valued aspects of housing design. Approximately 200 respondents ranked a list of design attributes, based on the concept of stated preferences. Results of this study are shown in Figure 6. Desired values and user satisfaction rates, especially in the city of Campinas, in the State of São Paulo, were established in earlier research. Cross-analysis of implementation costs and value delivered to end-users initiated by Ruiz (2011) forms the basis to validate the proposed evolutionary approach.

5. Evolutionary change in social housing design

Darwin was not the first scientist to rely extensively, in his scientific method, on compelling evidence of observations and reflections, which made him arrive at new insights and the formulation of theories. The careful and long period of observations and the often simple, but ingenious, tests conceived by Darwin however should be an inspiration in an endeavour to improve local social housing (Boulter, 2009). The many individual observations of housing in Brazil should be organized and characterized to give a scientific base for change. The Brazilian association for technology in the built environment (ANTAC) supports this endeavour through the HABITARE database, where important POE studies are available online.

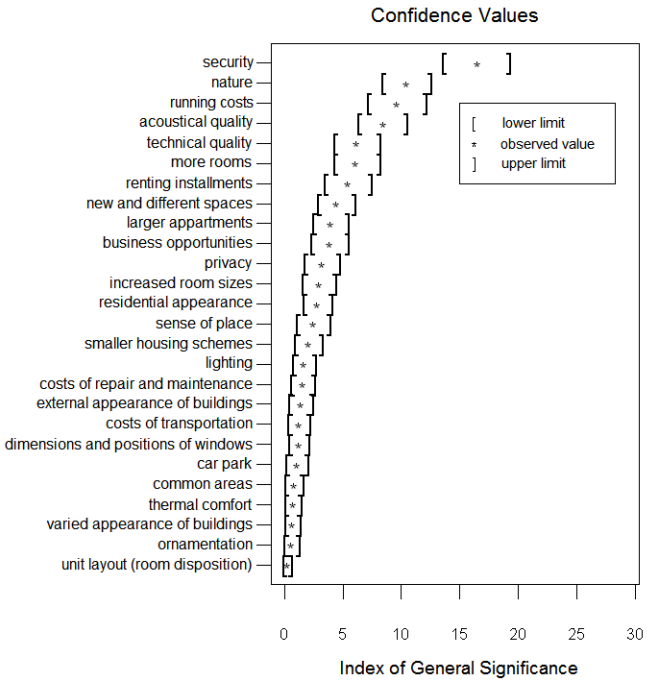


Figure 6: Perceived value of design quality items of social housing projects in Campinas, Brazil (Kowaltowski & Granja, 2011).

The many evaluations in the HABITARE database and data on user preferences (Figure 6) indicate that the current, less than ideal, local social housing design model needs improvements. From the evolutionary theory of Darwin we know that nature develops, through natural selection and in gradual small steps, specific characteristics in great variety to best-fit specific contexts (Dawkins, 1996). This idea can be used as an abstraction of a method to attain a better fit in mass housing design. Changes should occur in stages, as progressive improvements, thus through an evolutionary process. Here it is not nature that determines the positive improvements along an evolutionary process, but user preferences, technical observations and the dynamics of society and the construction industry.

In most social housing developments in Brazil, users are not the instigators of change, since they are typically only heard as far as satisfaction rates are concerned. With very low-income families these rates tend to be high when slum type dwellings or homes in risk area are substituted by social housing options. In the private housing market, users exert some form of impact, and buyers are shown to value specific aspects of housing trends. The market however first has to do its homework and overall assess, run functional tests and validate their financial feasibility, often expressed by (higher profits) sales. Other factors can be used in this scenario, such as: POE studies, retention of users in a specific location, and the increase in financial value of residential developments. In the social housing case, however, these factors cannot be applied, even though retention of families has often been implied as having an importance in this segment as well. Retention in the social housing market is however related primarily to the lack of choices low-income families have.

Other arguments must be found to give improvements an impulse in social housing in countries like Brazil. Security, for instance, is a major issue (Figure 6) and, as crime rates have been connected to negative housing conditions, these factors should be explored. As

few new solutions are tested in social housing and overall project changes are very rare, the proposal of incremental change presents itself as a viable idea to increase social housing quality. The step-by-step approach is important to convince social housing stakeholders (housing authorities, politicians, designers and planners, construction companies and end-users) of the true value in promoting an increase in quality of life indicators for the final users, or homeowners. Also, evolutionary change can be tested along the way, avoiding the substitution of an old model with a new, but not yet tried design typology. Perceived and desired values (Figure 6) can be used to act as persuasion arguments in the decision making process. Gradual change is of further importance for economic reasons, since small changes are less costly, technically more viable and less time consuming during the planning and construction phases of a project.

6. Opportunities for the introduction of improvements

Various opportunities for improvement to the given model were outlined in Kowaltowski and Granja (2011). These are outlined in Table 1 but can improve the existing design model only up to a certain extent. Evolutionary, incremental change only needs sporadic larger “mutations”, after simpler elements have been all dealt with (Figure 5). As in natural processes, systematic assessments are needed after every small evolution, to evaluate if and to which extent improvements are achieved and how user- and context-adapted they are. The discussion on the development of a “Darwinian model” to improve the design of social housing in the studied context can show that, although mass-produced, this type of architecture can evolve towards more customized, comfortable, more sustainable and higher quality homes. The improvements should be related to the perceived values of users as shown in Figure 6. Furthermore, technical observations and assessments should indicate priorities in relation to possible incremental design adaptations. The construction industry itself may bear pressure on changes for technical and productivity reasons.

User desires are overshadowed by security issues in Brazil, and humanization of social housing can only be achieved when urban crime is reduced and people feel safe enough to express other housing related desires, such as access to views with a substantial percentage of greenery, access to a garden to grow food and flowers, as well as having opportunities for healthy leisure activities. Better acoustic barriers on the urban scale and between residential units are also essential, since noise has been linked to aggressiveness in people and therefore creating insecurity.

A previous study conducted in housing developments of CDHU suggested site-planning changes at the design stage, which do not affect costs per residential unit, but allow for the introduction of small and incremental perceived improvements (Kowaltowski et al., 2006). Urban design that optimizes orientation of the built mass and bedroom windows, in particular, to reduce solar gain in a hot and humid climate can improve thermal comfort conditions and operational energy use at no construction cost premium. Also, reducing paved areas, but providing small car parks, with a vehicle space allocation for each housing unit, cannot only improve the urban landscape and vegetated open spaces, but also the form and location of land reserved for schools and other public services.

Table 1: Opportunities for improvement in CDHU housing projects in Campinas, Brazil

#	Improvement opportunities	Contributions toward:
1	Introduction of ceiling panel in bathrooms [Problem = visible sewer pipes of upstairs neighbour]	Privacy; Acoustic quality; Technical Quality
2	Personalized floor materials	Ornamentation
3	Plaster decoration detailing	Ornamentation
4	Exchange of Type of Front Door [Solid wood door = preference]	Security; Acoustic & Technical quality; Privacy & Ornamentation
5	Add a veranda to residential units as add-ons	Nature, Privacy and Thermal Comfort; Increase transitions spaces, improve shading conditions, allow outdoor activities, gardening
6	Allow openings in external end facades [Permit surveillance of building surrounding, parking lots, playgrounds, entrance to housing development; Permit joining buildings and creating various types of apartments (2 to 3 bedrooms)]	Security; Variety; Individualization
7	Installation of fence [Around compound and individual buildings]	Security; Sense of place- territoriality; Smaller housing scheme
8	Small business centres; Child care centre & Health centre Job opportunities [Security guards, Concierge; Small business owner; Employees of health and child care centre]	Business opportunities
9	Increase distance between windows of H-shaped buildings	Privacy; Acoustics; Dimensions and positions of windows
10	Elevate the ground floor apartments by 50cm above the entrance level	Security, Acoustics and Privacy
11	Introduce vegetated barrier between entrances and residential units at ground level	Nature, Privacy, Security, external Appearance, Ornamentation
12	Introduction of transition space in front of apartment door [Solution = Circulation removed from front door; Space for flower pots, personal decoration etc.]	Privacy; Security; Nature
13	Improve detailing of steps of stairs [Rough edges may cause accidents; Poor looking finishing]	Technical quality
14	Open the common stairs [Problem: lack of visibility – feeling of lack of security; Take out dividing wall]	Security; Common areas
15	Replacement of “community centre” by Barbecue area; Playground; Benches and Landscaping project	Nature; Ornamentation; Common areas
16	Individualize exterior of buildings through colour schemes	Ornamentation; Varied & Residential look; Sense of place
17	Permit door openings in party walls [allow joining of adjacent apartment spaces]	Larger apartments; More rooms, Increased room sizes; New and different spaces; Unit layout (room disposition)
18	Motorcycles (and bicycles) parking [Problem: burns from exhaust pipes]	Security; Car park
19	Site planning changes [Optimization of Orientation (sun and wind) of building blocks Optimization of community services will impact better building design; Increase urban tree planting; Plan for leisure activities; Optimize paved areas / reduce impermeable areas; Use of light colour pavements & envelope (roof and facades)]	Thermal comfort (increase shade, reduce heat gains); Avoid HVAC use; Sustainable use of energy resources; Improve rating of neighbourhood; Improve aesthetic aspects of housing projects; Increase retention of families

Ruiz (2011) applied value-engineering concepts to CDHU social housing. Since in a previous study (Kowaltowski et al., 2006) users indicated that the small community centre, part of these housing complexes, is rarely used and not considered as an important element in the housing scheme, the cost of this building could be re-allocated to cover the first six items from Table 1, actually valued by users (Figure 6), although not specifically in the same order of priority. Some of the improvements listed in Table 1 can be achieved through retrofitting, while others are more appropriate or more easily achievable with incremental design changes to new constructions. For instance, an additional ceiling panel in bathrooms (# 1 in Table 1) can be retrofitted, but lifting the building 50cm (# 9 in Table 1) above the main ground-floor entrance cannot. The addition of a veranda, though may be considered a rather large increment in change (mutation), is quite possible in existing developments as add-ons and good examples of such retrofits exist. Some retrofits, which support concepts of sustainability, have already been introduced in CDHU multifamily housing. Individual meters for water and electrical energy consumption have been installed. Other retrofits can be envisioned such as: programs for recycling of solid waste; solar water heater installations; shading devices for bedroom windows facing east, west and north; whitewashing exterior walls and roofs; replacing paving material of parking areas; interventions do improve landscaping (shading, green ground cover); rainwater collection from roofs (use for cleaning of exterior paving and watering of garden areas); installation of monitoring sensors; energy efficient lighting fixtures and presence sensor in public areas among others can be suggested.

7. Conclusions

This paper outlined changes that are considered important to be introduced into the social housing model provided by the State of São Paulo housing company, CDHU in Brazil. These propositions are inspired by analogies to Charles Darwin's scientific methods, based on careful observations and analysis. A further metaphor of Darwin's theory of natural selection was also presented. Thus, small incremental changes in the presently adopted housing design model are shown to be feasible in their introduction, even for a construction sector that works on bare minimum costs for provision of the maximum number of housing units. Retrofitting of existing projects is a viable option to improve housing quality on an incremental basis up to some extent, beyond which new designs are needed. Such design changes and improvement studies can be planned to best suit user values, as well as new technical recommendations that arise. Further research is suggested on several fronts. The extensive literature available on POE studies of design models similar to those adopted by CDHU should be systematically analysed, to identify new incremental changes from lessons learned. Secondly, the actual gradual changes occurring in local social housing models should be analysed. The recent large investments by the private and public sectors and the increasing pressures to include sustainability certifications in the construction industry as a whole in Brazil, may indicate interesting contributions toward improved social housing designs. Other studies should identify the limits of incremental change to old design solutions and the need for periodic adoptions of new models (total "mutations") in response to social and cultural dynamics and to significant changes occurring in the building industry. Furthermore, studies on true innovation in the social housing sector in developing countries

are paramount, to avoid the repetition of errors, improve peoples lives and advance in the science of architectural design and building construction as a whole.

References

Benedikt M.L. (2008), Human Needs and How Architecture Addresses Them, Austin, TX, USA, University of Texas Press.

Boulter M. (2008), Darwin's Garden: Down House & the Origin of Species, London, UK, Constable & Robinson Ltd.

Broadbent G. (1973) Design in architecture: Architecture and the human sciences, London, UK, John Wiley & Sons.

CABE (2009_a) Resident satisfaction with space in Homes, London, UK: Commission for Architecture and the Built Environment.

CABE (2009_b) Space in new homes: What residents think, London, UK: Commission for Architecture and the Built Environment.

Carmona M. (2001) Housing Design Quality through Policy, Guidance and Review, London, UK, Spon Press.

Choguill C.L. (2007) "The search for policies to support sustainable housing", Habitat International, Vol. 31 No. 1, pp. 143–149.

Cross N. (Ed.) (1984) Developments in Design Methodology, Umi Research Pr, NY, USA.

Darwin C. (1859) On the Origin of Species, London. UK, Empire Books, 2011 edition.

Dawkins R. (1996) The Blind Watchmaker: Why the Evidence of Evolution Reveals a Universe without Design, W. W. Norton & Company, NY, USA.

Ferguson B. and Navarrete, J. (2003) "New approaches to progressive housing in Latin America: A key to habitat programs and policy", Habitat International, Vol. 27, No. 2, pp. 309–323.

Figueiredo F G (2009) Processo de Projeto Integrado para melhoria de desempenho ambiental de edificações: dois estudos de caso, UNICAMP, Campinas, Brazil (MSc Dissertation),

Jones J C (1970) Design Methods, Wiley, 2nd ed, NY, USA.

Kowaltowski D C C K and Granja A D (2011) "The concept of desired value as a stimulus for change in social housing in Brazil", Habitat International, Vol. 35, No. 3, pp. 435–446.

Kowaltowski D C C K, Silva V G, Pina S A M G, Labaki, L C, Ruschel R C and Moreira D C (2006) “Quality of life and sustainability issues as seen by the population of low-income housing in the region of Campinas, Brazil”, Habitat International, Vol. 30, No. 4, pp. 1100–1114.

Preiser, W F E and Vischer J C (Eds.) (2004) Assessing Building Performance, Elsevier Butterworth-Heinemann, Oxford, UK. .

Ruiz J A (2011) Engenharia de valor na construção de edifícios: simulação de aplicações UNICAMP, Campinas, Brasil. (MSc Dissertation),

Rittel H W J and Webber M M (1973) “Dilemmas in a general theory of planning”, Policy Sciences, Vol. 4, No. 2, pp. 155–169.

Spencer N C and Winch G (2002) How buildings add value for clients, London, UK, Thomas Telford Ltd.