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Handy home improvements: a proposal for a prototype web application for technical assistance in social housing

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ABSTRACT

In the face of the pressing challenges posed by the COVID-19 pandemic, the role of architects and urban planners in delivering evidence-based technical assistance for social housing (TASH) has become more crucial than ever. This article outlines the stages and methodologies employed in developing a prototype web application titled "*Reforma na Palma da Mão*" (Handy home improvements). The project was funded by CAU-MG under Public Notice 001/2021, focusing on the theme "Healthy Home – Decent Housing." The characteristics, structure, and proposed graphical interface for the application are highlighted, as designed to provide information on alterations with a focus on functionality and thermal comfort in social housing (SH) units of the Brazilian *Minha Casa, Minha Vida* (PMCMV) housing program. These are attributes of the built environment most directly associated with health, particularly relevant in the face of the consequences of the COVID-19 pandemic on living conditions – such as the need to study/work from home and the provision of thermal qualities required for the successful execution of these activities in indoor environments. The paper highlights the importance of User-Centered Design (UCD) and Post-Occupancy Evaluation (POE) as methodologies that facilitate the development and web-based delivery of tailored alteration guidance strategies, aligned with the characteristics and needs of the target audience. The article also describes the usability testing process of the proposed application, highlighting its potential for use by wider audiences interested in the construction and alteration of SH. Thus, residents, service providers, and architects and urban planners involved in the production of healthier through the reported pilot project.

KEYWORDS

Social Housing;
Web application;
COVID-19;
Thermal Comfort,
Functionality

Reforma na palma da mão: uma proposta de aplicativo web para assistência técnica em habitação de interesse social

RESUMO

Frente às urgências impostas pela pandemia de COVID-19, a ação do arquiteto e urbanista por meio da prestação de assistência técnica para a habitação de interesse social (ATHIS) baseada em evidências nunca foi tão relevante. O presente artigo descreve as etapas e metodologias envolvidas na concepção do Artefato Piloto WebApp intitulado "Reforma na palma da mão", desenvolvido sob patrocínio do CAU-MG - edital 001/2021, abordando o tema “Casa saudável – Moradia digna”. São destacadas as características, estrutura e interface gráfica propostas para o Artefato, concebido visando fornecer informações sobre reformas com enfoque na funcionalidade e conforto térmico em habitações de interesse social (HIS) do Programa Minha Casa, Minha Vida (PMCMV). Esses são atributos do ambiente construído mais diretamente associados à salubridade, especialmente relevantes frente às consequências da pandemia de COVID-19 sobre o morar – tais como a necessidade de estudar/trabalhar em casa e o suprimento das qualidades térmicas exigidas para boa realização dessas atividades nos ambientes domésticos. O artigo destaca o papel do Design Centrado no Usuário (DCU) e Avaliação Pós-Ocupação (APO) enquanto metodologias capazes de viabilizar a elaboração e oferta via WEB de estratégias de orientação de reformas coerentes às características e necessidades do público-alvo. O artigo também descreve o processo de testagem da usabilidade do Artefato proposto, destacando seu potencial de aproveitamento por parte de quaisquer usuários interessados na construção e reforma de HIS. Assim, moradores, prestadores de serviços e arquitetos e urbanistas engajados na produção de HIS mais saudáveis e resilientes encontram subsídio para suas atividades por meio do projeto piloto ora relatado.

PALAVRAS-CHAVE

Habitação de interesse social;
Aplicativo web;
COVID-19;
Conforto Térmico;
Funcionalidade

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1 INTRODUCTION

This article aims to present the design process of a prototype web application focused on guiding and evaluating alterations, with a focus on promoting technical assistance for social housing to achieve more thermally comfortable and functional living environments.

Based on the knowledge and experiences gained by the **[MORA] Housing Research** Group from the Faculty of Architecture, Urban Planning, and Design at the Federal University of Uberlândia over the course of 12 years of research in housing, it is understood that the role of the architect and urban planner, through the provision of technical assistance for social housing (*Assistência técnica para habitação de interesse social*, TASH) based on evidence has never been more relevant. Given the urgencies imposed by the COVID-19 pandemic and aiming to promote better living conditions for people facing social vulnerability, the proposal of the application in question is justified. It serves as a complementary measure to tackle the pandemic by addressing issues related to functionality and thermal comfort, which are among the most affected aspects of housing amidst the current health crisis. This underscores the significance of architects and urban planners in interpreting the needs of individuals, communities, and social groups, with the aim of ensuring the promotion of well-being, health, and human dignity. Simultaneously, the Application will act in the production and promotion of knowledge in the field of TASH, aiming to disseminate, develop, implement, and strengthen the Federal Law No. 11.888/2008. This will be achieved through the provision of technical materials (web application and booklets, in pilot version) based on evidence, capable of enabling and enhancing professional practice within this area, which is in great need of attention from public administration, professional organizations, and civil society.

The present work proposal falls within the scope of the ongoing institutional research [RESILIENT HOUSE] Design strategies for promoting resilience in social housing from post-occupancy evaluation methods. This research is funded by the National Council for Scientific and Technological Development - CNPq (Productivity in Research Scholarship – PQ Number 311624/2021-9, from 2022/2025). The research has utilized Post-Occupancy Evaluation (POE) instruments that assess the perception and degree of discomfort caused by the impacts commonly incident on social housings (SH) of the Minha Casa, Minha Vida (MCMV) program (Villa, Bortoli e Vasconcellos, 2023a - Duly reviewed and approved by the Ethics Committee for Research Involving Human Subjects at UFU (CEP/CONEP/UFU) under CAAE Number 64272022.6.0000. 5152). As a result, the research group has been developing guidance strategies for the alteration and design of more resilient SH projects, focusing on both users and designers. These strategies are available on the CASA RESILIENTE website.

Thus, this Application provides a set of practical solutions aiming to enhance the functionality and thermal comfort (including humidity and ventilation) of SH within the MCMV program, while addressing issues more directly related to the healthiness of the living spaces in the face of the coronavirus. Initially, a target audience of 20 dwellings located in the social housing complex (SHC) of the Shopping Park neighborhood (Uberlândia, MG) was evaluated in order to understand, more specifically, how they have perceived the impacts and changes caused by the pandemic. The intention was to analyze the spaces of the residences regarding their capability to accommodate new functional needs (work, study, leisure, hygiene, storage, etc.), as well as their capacity to provide thermally comfortable and suitable conditions.

This article focuses on describing the processes and techniques developed for the elaboration of the Prototype web application, highlighting its characteristics, proposed structure, and graphical interface. Based on the expertise of the MORA group, validated in conjunction with potential users – residents of horizontal social housing (single-story houses), the application simultaneously combines the functions of providing guidance and evaluating alterations.

2 RESILIENCE IN THE BUILT ENVIRONMENT AND TECHNICAL ASSISTANCE IN SH IN UBERLÂNDIA (MG)

Horizontal social housing (SH) provided by the Brazilian housing program Minha Casa, Minha Vida (MCMV) have been failing in terms of their adaptability to the climate and the evolving demands of their users over time (Bortoli *et al.*, 2024; Oliveira e Villa, 2024a; Villa *et al.*, 2022a; Bortoli, 2023). Floor plans and construction specifications offered by the program are repeated in different Brazilian climatic regions, causing thermal discomfort during its use and operation phase (Bortoli *et al.*, 2023; Vasquez, 2017; Brasileiro, Morgado and Luz, 2017; Triana, Lamberts and Sassi, 2017; Amore, Shimbo and Rufino, 2015).

After a few years of occupancy and use, the residents intervene on the minimal housing, starting with the expansion of its built area, in order to better accommodate their needs and aspirations.

This process usually takes place through "weekend alterations," without the involvement of construction professionals (Simões, Leder, & Labaki, 2021; Pela, 2020). The construction rigidity, characterized by the use of load-bearing masonry in this housing typology, restricts interventions, along with the positioning of the embryo environments on the lot without considering future connections with expansions (Villa et al., 2022a). The result is the obstruction of bedroom and living room windows and the creation of poorly optimized circulation which compromise the functionality and thermal comfort for the residents.

According to the Brazilian Council of Architecture and Urban Planning (CAU), the inadequacy of social housing is directly linked to the absence of TASH. Furthermore, informality exacerbates the inadequacy as it introduces uncertainty into housing due to the construction without professional technical assistance (CAU/SC, 2020).

Since 2008, the Brazilian Law of Technical Assistance for Social Housing, 11.888, ensures that low-income families have access to free public technical assistance for the design and construction of SH. However, due to reduced application, it fails to provide technical assistance to those in need.

Meanwhile, studies have found that architects lack access to reliable information on successful models and approaches for SH, and there are limited ways for experienced professionals to share their methodologies and field experiences (Ahrentzen, 2006).

These issues denote a situation that poses a threat to the health, well-being, and dignity of social housing residents. Loche, Fonseca, and Carlo (2018) and Simões, Leder, and Labaki (2021) predict a tendency towards complete lot densification in low-cost housing through self-construction. In addition to that, the sanitary emergency imposed by COVID-19 and overheating of built environments derived from climate change (Nishiura *et al.*, 2020; IPCC, 2022) further highlight the need for urgent changes in the design process and post-occupancy assistance in Brazilian HIS (Oliveira e Villa, 2024b).

According to Roaf and Nicol (2017), these changes should occur in three ways: 1. The buildings will be designed/modified to withstand higher temperatures; 2. Buildings will be increasingly heated and cooled using natural energy whenever possible; and 3. People will regain control over adaptation

opportunities in the environments they occupy by using a range of manual and mechanical means.

The resilience of the built environment is a quality guidance in this process, manifested through the ability of both the house and its occupants to withstand, adapt and/or transform themselves to deal with various impacts over time (Garcia and Vale, 2017; Rodin, 2015; Pickett *et al*., 2014). This ensures the maintenance of the functionality and the core of the housing system, favoring the well-being of those who live in it, and thus achieving the realization of the "social interest" advocated by housing programs.

Since 2017, the Council of Architecture and Urban Planning of Brazil (CAU), along with its state units, has allocated 2% of its revenue to promote free, high-quality technical assistance for SH. In this context, the CAU recognizes Technical Assistance for Social Housing as a fundamental human right, aiming to bridge the gap between architecture and urban planning and the low-income population (Amirati, 2019, p. 64).

2.1 The experience of the [MORA] Housing Research Group

Research conducted by the [MORA] Housing Research Group at the Faculty of Architecture, Urban Planning, and Design (FAUeD) of the Federal University of Uberlândia (UFU) has highlighted key issues faced by social housing communities (SHC) in Uberlândia, Brazil, which were explored in previous undergraduate and postgraduate studies.

The work entitled "RESILIENCE AND ADAPTABILITY IN SOCIAL HOUSING COMPLEXES THROUGH COPRODUCTION" is one such project, funded by the Council of Architecture and Urban Planning of Minas Gerais - CAU-MG/TASH No. 02/2019, between July 2019 and April 2020. Innovative methodologies for TASH have been developed and applied in horizontal SHC to address five main problems identified by the group in the case study: low thermal performance, storage difficulties, poor acoustic performance, lack of green areas, and accumulation of debris and waste (Villa *et al*., 2021; Villa e Funari, 2022).

Villa *et al.* (2022b) also reported an experience of Post-Occupancy Evaluation (POE) conducted in both horizontal and vertical SHC in the city of Uberlândia/Brazil, between 2018 and 2019, observing the recurring problems in these dwellings and the discomfort experienced by their residents, drawing attention to:

- The heat inside the house, which was bothersome for 73% of the respondents;
- The occurrence of humidity and mold, which was bothersome for 75% of the residents;
- The sensation of stuffiness in rooms, which bothered 78.3%;
- The fact that more than 50% found all the rooms in the house too small for their needs;
- The difficulty of fitting furniture in 58% of cases;
- The fact that more than 90% carried out alterations.

Another study conducted by the group in 2022 provided an analysis of the impacts of COVID-19 on housing through the administration of a virtual questionnaire, which gathered 468 responses (Villa *et al.*, 2022c). The applied questionnaire investigated housing conditions before and during the pandemic, with questions about well-being, engagement, accessibility, flexibility, environmental comfort, and environmental suitability. Among the responses, the following stood out:

- The fact that 38% expressed dissatisfaction with the capacity of the house's spaces to accommodate activities such as work and study (which became significant in the context of remote work and social isolation);
- 20.1% felt dissatisfied with the number of bedrooms in relation to the number of residents;
- 16.2% felt dissatisfied with the thermal sensation;
- 12.3% felt dissatisfied with the natural ventilation;

Also, research conducted by the group has also demonstrated the effectiveness of technological tools for assessing environmental quality in SH and the dissemination of guidelines through socially accessible and durable information (Villa *et al.,* 2023b; Garrefa *et al*., 2021; Villa *et al.*, 2020a; Villa *et al*., 2020b).

Between October 2021 and June 2022, the group was sponsored by the public call notice no. 001/2021 from the Council of Architecture and Urban Planning of Minas Gerais (CAU-MG), with the theme "Healthy Home - Dignified Housing," through the project entitled "ESTRATÉGIAS 'NA PALMA DA MÃO' PARA UMA CASA SAUDÁVEL E RESILIENTE ("STRATEGIES FOR HANDY HOME IMPROVEMENTS FOR A HEALTHY AND RESILIENT HOME)".

The project aimed to promote better living conditions for communities in situations of social vulnerability, in response to the COVID-19 pandemic in Minas Gerais, Brazil. This edition particularly supported proposals focused on improving social housing, with an emphasis on enhancing the dwellings, particularly the plumbing installations, building pathologies, thermal comfort (ventilation system, lighting), and environmental quality, with the goal of complementing and supporting actions to combat the pandemic (CAU-MG, 2021).

The web application pilot application nicknamed "*REFORMA NA PALMA DA MÃO*" (Handy home improvements) was the result of this work, serving as the group's response to the desire to expand the reach of their ongoing actions based on the [RESILIENT HOUSE] research. Thus, the main objective of the work was the development of a prototype application to provide information guiding alterations aimed at enhancing the functionality and thermal comfort of horizontal social housing under the MCMV program. It focused on housing aspects particularly impacted by the COVID-19 pandemic, with the goal of achieving healthier and more resilient living conditions. Therefore, the intention is to improve this prototype web application within the context of the ongoing [RESILIENT HOUSE] research.

3 METHODOLOGY AND CASE STUDY

The prototype web application REFORMA NA PALMA DA MÃO, was developed in partnership between the Faculty of Architecture, Urban Planning, and Design, and the Faculty of Computing of the Federal University of Uberlândia (FAUeD/FACOM/UFU), sponsored by CAU-MG.

The research was based on the Hypothetico-deductive Design Science Research (DSR) method, which emphasizes creating artifacts as outcomes by developing solutions for existing systems (Dresch, Lacerda, Antunes Júnior, 2015). An artifact is an object constructed using scientific methods, making it capable of generating knowledge (Reis, 2019).

Thus, it was supported by well-established research and work methodologies in the field of Design: User-Centered Design (UCD) through Design Thinking and Double Diamond; Architecture and Urban Planning: Post-Occupancy Evaluation; and Computing: Back-end and Front-end development.

User-Centered Design (UCD) is a design approach that places the needs and desires of users at the center of the design process. This approach is based on a profound understanding of users, their behaviors, habits, motivations, and expectations, aiming to create design solutions that are effective, efficient, and satisfying for them.

Hassenzahl *et al.* (2010) emphasizes the importance of understanding users' emotions for UCD. According to Vaconcelos *et al.* (2021), UCD should be able to relate to users' social practices, symbols, preferences, and emotional needs. By doing so, the risks of project failure are minimized.

According to Eggen, Van Den Hoven, and Terken (2014), designing to ensure the best user experience requires a holistic approach in which system components, such as functionality, interface, and appearance, address basic human needs.

A study conducted by Haines and Mitchel (2014) demonstrated the extent of human subjectivity in the implementation of technologies for energy retrofitting of housing in the United Kingdom. The authors conducted field research with users of historic housing to understand their attitudes, motivations, and difficulties regarding the implementation of alterations. As a result, they identified representative personas that support the creation of more assertive intervention strategies tailored to the practices and expectations of the target audience (Frances e Stevenson, 2019; Gram-Hanssen, 2009).

Parallel to this, Guerra-Santin *et al*. (2017) studied the relationship between users' preferences and expectations and their energy demands in historic residential buildings with similar typologies. The study found that even in similar typologies, demands and behaviors regarding housing management and its subsystems vary according to other less predictable factors, such as knowledge, expectations, income, and other symbolic issues of each individual. It was also observed that before engaging in energy retrofitting campaigns involving high expenses and habits changes, people would like to have an idea of how their houses would look like and the consequences of certain interventions on the overall outcome. The research participants also reported that they would like to see examples so that they could make more consciously informed decisions about the investment.

The results of this study coincide with the conclusions of Branquinho (2022), who observed that the more people are involved in the design and interventions in their homes, the better satisfied they feel with the achieved outcome.

All these studies demonstrate the importance of understanding the subjective demands of users of technological products before offering them and even imposing them on the market. In this regard, Sanders and Stappers (2008) argue that UCD is an iterative approach that involves continuous cycles of observation, analysis, prototyping, and testing. The study emphasizes that the iterative process is fundamental to UCD as it enables designers to continuously improve their design solutions based on user feedback, obtained through usability testing.

Usability can be understood as the extent to which a system, product, or service can be used by specific users to achieve specific goals with effectiveness, efficiency, and satisfaction in a particular context of use (ISO 9241-11, 1998). With this, it considers meeting basic human needs, such as relationship, self-realization, and self-esteem (Eggen, Van Den Hoven e Terken, 2014).

The Design Thinking methodology aligns with UCD, emphasizing collaboration, experimentation, optimism, and the graphical visualization of information. It offers a procedural framework for the design team, supporting the understanding of the problem, its exploration, resolution, and realization. According to Gibbons (2016), these three stages involve subprocesses such as empathy with the user, definition, ideation, prototyping, testing, and implementation.

The process aims to produce designs that meet the actual needs of users, not just those that are imagined. Then, the applications are tested with real users. This process values collective experience promotes shared language, and cohesion within the team, as well as encourages innovation by exploring different approaches to solving the same problem (Gibbons, 2016). The Double Diamond diagram, in turn, is a framework for organizing the common procedures in any UCD process, divided into four phases: discovery, definition, development, and delivery. It organizes divergent and convergent stages of the creative process (Figure 1), represented by lines that separate and come together during a project's process, resembling the shape of two diamonds (Garcez, 2017).

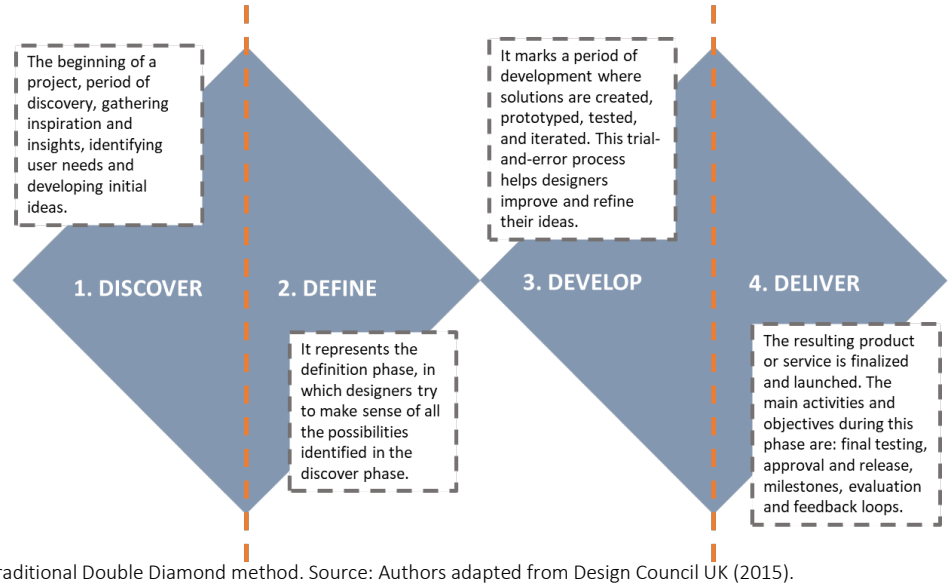


Figure 1 The traditional Double Diamond method. Source: Authors adapted from Design Council UK (2015).

This methodology was created by the Design Council (2015), a British organization that promotes the use of design to innovatively solve complex problems. When it comes to creating applications, the Double Diamond methodology can be very useful. In the discovery phase, for example, it is possible to understand the users' needs and preferences. In the definition

phase, the objectives of the application can be established, and the functionalities it should have can be defined. In the development phase, it is possible to test prototypes and improve the application's design before reaching the delivery phase.

Indeed, Post-Occupancy Evaluation (POE), as a data acquisition methodology specific to Architecture and Urban Planning, contributes to the discovery stage proposed by the Double Diamond. The relevance of POE for achieving architectural design quality has been proven by studies in the field of civil construction, both in the Brazilian and international contexts. The use of systematized outcomes from POE can fuel public policies and design and planning practices that better address people's needs, particularly in contexts where the client's individuality is not directly addressed, as is the case with Brazilian social housing (SH) (Van Der Voordt e Wegen, 2013; Ono *et al*., 2018; Roaf, 2004; Leaman, Stevenson e Bordass, 2010; Preiser, Hardy, e Schramm, 2018; Li, Froese e Brager, 2018).

This methodology brings together a variety of research techniques that support the gathering of performance-related information, along with user opinions regarding certain established values/objectives. The methodologies used may include interviews, walkthroughs/guided tours, questionnaires with open and/or closed-ended questions, focus groups, among others. The choice between these methods will depend on the evaluation's objectives, the availability of information, and the ease of access to the evaluated location and research subjects (Kowaltowski *et al.*, 2011; Finch, 2012; Baker e Steemers, 2019; Stevenson, 2020).

Methods in computer science also supported the development of the pilot web application through technologies such as databases, programming languages, and frameworks for both front-end and back-end implementation. However, their discussion will not be further explored in this article.

3.1 Stages of work and the Double Diamond

For the development of the prototype web application, five stages of work were followed, in line with the phases of the Double Diamond diagram:

STAGE 1: Adaptation of the questionnaire and ethical approval

Objective: This stage aimed to adapt a previously used impact questionnaire by the research group to assess the perception of the impacts caused by the COVID-19 pandemic on the functionality and thermal comfort of the social housing in the case study. The questionnaire was submitted to and duly approved by the Ethics Committee for Research Involving Human Subjects at UFU (CEP/CONEP/UFU) for ethical approval of the proposed POE instrument, under CAAE Number 64272022.6.0000.5152.

STAGE 2: Application of the research instrument

Objective: This stage aimed to initially select and approach 20 research subjects for the application of the questionnaire developed in Stage 1 (see Table 1). The results of this stage provided the basis for developing content to inform better alterations, aiming to achieve thermal comfort and functionality.

STAGE 3: Elaboration of informative material

Objective: This stage aimed to describe how the results from Stage 2 guided the conception of the prototype web application, in terms of approach strategies, content, UI and UX design, graphic design, graphical interface, and programming.

STAGE 4: Testing and improvement of the elaborated material

Objective: This stage aimed to apply the elaborated materials to the project's target audience in order to collect information that would support their improvement through usability testing (see Frame 1), to better meet the expectations and needs of the users.

STAGE 5: Dissemination

Objective: This stage aimed to disseminate the produced and improved material, in its pilot version, to the project's target audience.

For each stage and design phase, support tools and information acquisition were used, as illustrated in Figure 2. Frame 1, on its turn, summarizes the POE tools conceived and performed.

3.2 Case study in Uberlândia/Brazil

The research's target audience included 20 residents of a horizontal social housing complex called RSB, located in the Shopping Park neighborhood in the southern sector of Uberlândia, MG. This complex is part of the Minha Casa, Minha Vida (MCMV) program. The final product of the partnership (formatted as a prototype web application and digital and physical handbooks) will be intended for the participating residents, with the possibility of virtual dissemination for residents of other horizontal social housing complexes under the Minha Casa, Minha Vida program (income bracket 1 - 0 to 3 minimum wages), service providers, architects, and urban planners residing in bioclimatic zone 4 (the same zone as Uberlândia) who are involved in or interested in conducting alterations in social housing (SH).

The SHC in the Shopping Park neighborhood was the first horizontal development under the Minha Casa, Minha Vida program to be launched in the city of Uberlândia/Brazil, between the years 2010 and 2011. The development comprises 3,632 horizontally paired housing units, provided for the income level 1 of the Minha Casa, Minha Vida program (which ranged between 0 and 3 minimum wages). It consists of 8 contiguous plots, among which the RSB plot was chosen as the case study (Figure 3).

The paired housing units have a total area of 37.91 square meters each, including a living room, kitchen, two bedrooms, one bathroom, an external service area, and a solar water heating system for the bathroom (Figure 4).

The housing units underwent numerous alterations and expansions between the years 2010 and 2020, as can be observed in Figure 5. The subdivision had its physical, urbanistic, environmental and social conditions extensively evaluated through extension projects and postgraduate research, as previously reported. The studies of Bortoli and Villa (2020), Parreira (2019) and Araújo and Villa (2020) are relevant for the present work.

1

DISCOVER

Step 1: adequacy of the questionnaire and ethical assessment

- Objectives: product discovery, understanding of product viability, adequacy of the impact questionnaire produced by the group to assess impacts related to functionality and thermal comfort in SH during a pandemic period, and preparation and submission of a research protocol for ethical consideration.
- Methodology and tools: Design Thinking, through a matrix of assumptions and doubts, 5W2H, brainstorm and categorization and POE, through the development of a questionnaire and walkthrough script.

2

DEFINE

Step 2: application of the research instrument

- Objectives: understanding the specific needs of users, preparation of a roadmap for application, training for application, application, tabulation of results and analysis.
- Methodology and tools: Design Thinking, through categorization of discoveries in themes and in priority/effort and POE, through questionnaires and walkthroughs and diagnostic maps by houses.

3

DEVELOP

Step 3: Designing the WebApp Pilot Artifact

- Objectives: development of screens and navigation flow, attribution of visual identity to the project, development of own illustrations, graphic development, creation of contents, development of the website, improvement of the database.
- Methodologies and tools: Design Thinking – prototyping stage, through Figma and Illustrator applications; HTML, CSS, PHP and Bootstrap via Notepad++

4

DELIVER

Step 4: testing and improving the prepared material

- Objectives: preparation of the usability test script, application of tests, understanding of usability problems, improvements.
- Methodology and tools: Design thinking – test stage, using paper scripts, Figma and direct access to the WebApp Pilot Artifact.

Step 5: Dissemination of the material produced

- Objectives: virtual sending of the material produced to participating residents, face-to-face approach to residents, delivery of promotional materials, photographic record.
- Methodology and tools:-

Figure 2 Relationship between Double Diamond phases, work stages, methods, and tools used.

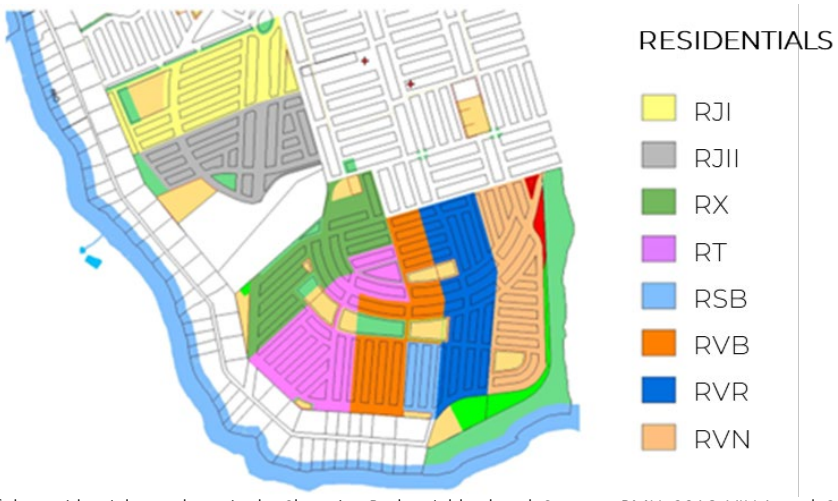


Figure 3 Map of the residential complexes in the Shopping Park neighborhood. Sources: PMU, 2016; VILLA et al, 2017.

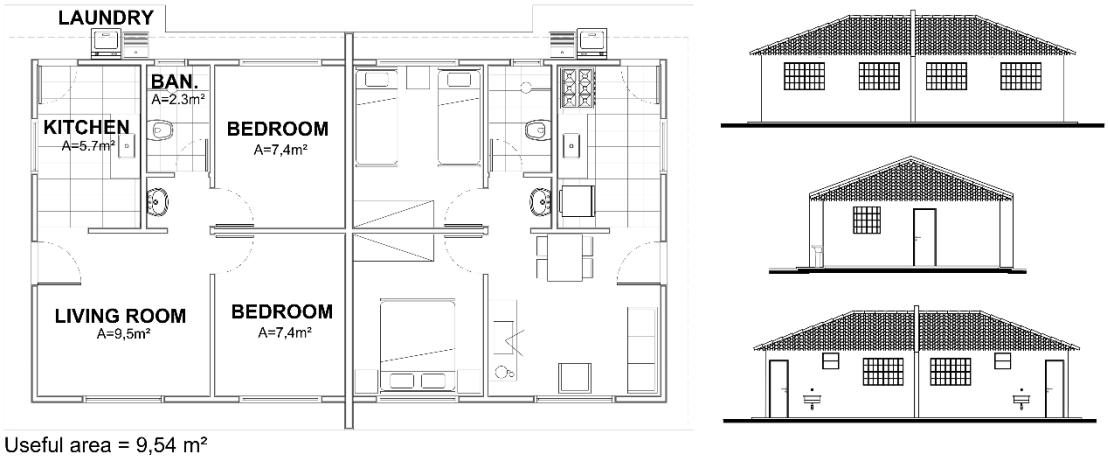


Figure 4 Floor plan and views of the standard paired housing units in RSB. Source: PMU, 2016.



Figure 5 Densification of RSB between the years 2010 and 2020. Source: casaresiliente.com.

Frame 1 POE Instruments.

Evaluation instruments	Impact questionnaire (IQ)	**Description:** Qualitative method that collects data through open-ended questions with individuals involved in the evaluation process (Yin, 2009; Villa *et. al.*, 2022) **Objective:** The objective of the questionnaire is to identify discomforts with the house, new demands arising from COVID-19, information about alterations, guidelines, and the conditions of the rooms regarding functionality and thermal comfort. **Organization of the instrument:** The instrument is organized to respond to the following 6 questions: 1) What are the general characteristics of the target audience: income and alterations, internet access, and sources of information about alterations?; 2) What are the discomforts with the house in general (regardless of the restrictions imposed by COVID-19)?; 3) What are the new demands with the house arising from COVID-19?; 4) What do participants think about possible/necessary alterations to address discomforts?; 5) What do people think about professional guidance in carrying out alterations?; and 6) What are the housing conditions related to thermal comfort and functionality, and what are the consequences of previous alterations on these aspects? **Method of application:** Printed questionnaires **Application period:** 12/04 and 12/09/2021 **Sample:** 20 research subjects **Selection criteria:** The aim was to investigate all the streets within the defined area.
	Usability testing	**Description:** Qualitative method **Objective:** Application of the developed materials to the project's target audience to collect information that would support their improvement, to better meet the expectations and needs presented. **Organization of the instrument:** The instrument is organized into two parts: the participant's form, which includes instructions and tasks, and the researcher's form, which consists of distinct tasks: Researcher 1 is responsible for the interactions with the participant, filling out the participant's form, and recording the audio of the test, while Researcher 2 is in charge of timing the test, taking photographic records of the test, and filling out the researcher's form. **Method of application:** Printed questionnaires. **Application period:** 05/21 and 05/25/2022 **Sample:** 10 research subjects. **Selection criteria:** The aim was to investigate all the streets within the defined area.

(Source: Developed by the authors

Bortoli and Villa (2020) characterize the low thermal comfort of the housing units (HU) of its case study that are derived from conditions inherent to the project and its execution as well as from interventions carried out by the residents themselves without technical assistance. The use of construction materials with performance below the recommended for bioclimatic zone 4, in which the city of Uberlândia is located, along with the construction of new rooms that often obstruct openings contribute to more than half of the residents evaluating their homes as hot and stuffy and depending on the use of mechanic devices to attenuate the thermal sensation.

Parreira (2019) found the construction system in load-bearing masonry and the reduced dimensions of the HU environments restrict the possibilities of spatial remodeling to accommodate different uses from those for which they were initially thought, compromising their flexibility. Finally, Araújo and Villa (2020) observed a relationship between the characteristics of the built environment of the SH and the 5 actions that define well-being (to connect, to continue learning, to take knowledge, to be active, and to give). They highlighted as the main obstacles to the proper accomplishment of these actions in the set: the lack of acoustic privacy between units and between rooms of the houses; the small size of the units; the overlapping of uses and low responsiveness of the environments to properly accommodate the uses, the isolation, and lack of urban quality of the set.

Through the conducted research, it was possible to verify the unpreparedness of the housing units in the selected case study to adapt to the physical changes demanded under normal conditions, indicating, among other issues, their low functionality and thermal comfort, symptomatic of a scenario with low resilience. The consequences generated by the pandemic, such as job loss, reduced family incomes, and the induction of cohabitation situations, coupled with the imposed social isolation measures, have placed social housing users face to face with the reality of their homes for longer periods than usual, highlighting and even magnifying the existing problems.

4 RESULTS

The results were organized according to the work stages and will be detailed in the next three sections: the diagnosis resulting from the assessments with residents; the proposal, based on the structure of the prototype web application and the solutions for the identified problems; and the usability test aimed to evaluate the use of the prototype web application interface.

4.1 Evaluation: residents' information and opinions

Initially, the impact questionnaire was adapted to assess the perception of the impacts caused by the COVID-19 pandemic on the functionality and thermal comfort of the social housing in the case study. Subsequently, the subject selection and recruitment for questionnaire administration and technical analysis were carried out, followed by the application of the research instrument.

The visited streets and houses were identified with codes to preserve the participants' identity. 20 questionnaires were administered. Among them, in 14 houses, it was possible to conduct visits for technical analysis and records (photos, videos, and sketches), supporting additional analysis to complement the questionnaire (Figure 6), using schematic floor plans, photographs, and general information about materials and furniture observed in the houses.

The results of the questionnaires were analyzed aiming to answer the following questions, aligned with the objectives of the instruments. The results are summarized in Figure 7.

1. What are the general characteristics of the target audience including income and alterations, internet access, and sources of information about alterations.
2. What are the general complaints about the house? (Regardless COVID-19 imposed restrictions)
3. What new demands for household have emerged during COVID-19? What do people think about making possible/necessary alterations to solve inconveniences?
4. What do participants think about professional guidance on alteration projects?
5. In terms of thermal comfort and functionality, what are the house conditions and what are the consequences of previous alterations on these aspects?

In the following paragraphs, we summarize the findings for each question.

Question "1. What are the general characteristics of the target audience: income and alterations, internet access and sources of information about alterations?", most of the respondents were women aged 20-59 years and all of them had at least mobile internet access. The majority (11 out of 20) had completed high school and no respondents had never attended school.

Regarding the income, 6 out of 20 respondents earn less than minimum wage and 9 earn between 1 and 3 times the minimum wage. All of the households with no income or income below minimum wage had 3 or more occupants.

All respondents had already made alterations to their homes and for 14 of them this decision is based on financial status. Concurrently, 14 out of 14 houses (among those visited for technical analysis) were expanded, 10 of these remain incomplete, mostly lacking finishes.

13 out of 20 respondents do not search for information about alterations, follow their own ideas or leave it to the contractors. And 6 out 20 respondents research the internet - Google and YouTube. Money is a key factor to start making alterations as well as to finish them. Dealing with small spaces and the need to accommodate family members, many people invest their limited resources into alterations with no prospects of completing it and end up living in potentially unsafe and uncomfortable unfinished places.

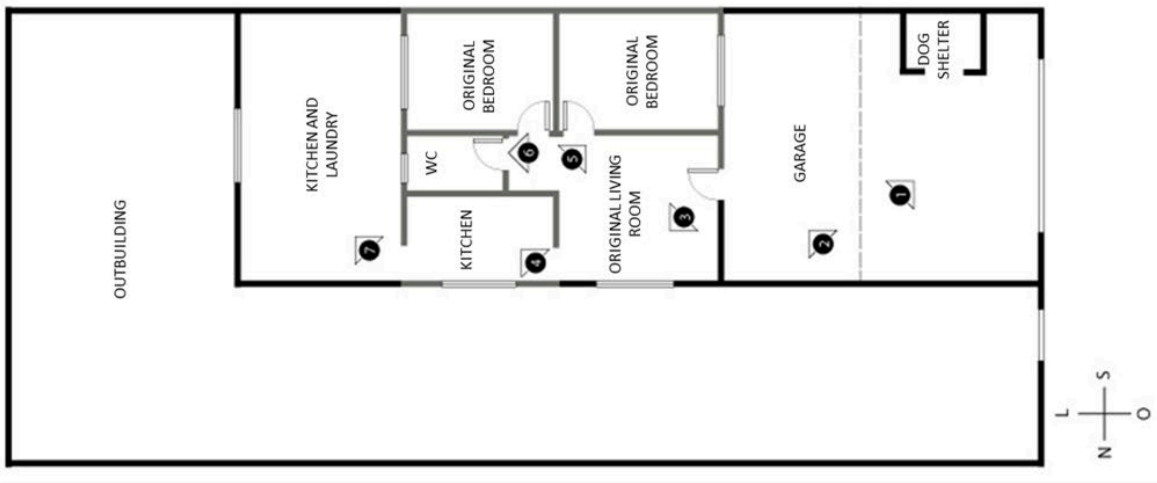
In regards to question “2. What are the general complaints about the house?” only 5 of 20 residents would not like to build another room, what might be explained by the fact they had already expanded their houses by the time of the interview. Among those who would like a new room, priorities are bedroom, bathroom and porch, in this order.

Amidst the most common additions are utility rooms, kitchens and bedrooms. It is also noticeable how all respondents had partially or totally cemented or paved their land lot (Figure 8). 7 out of 20 respondents admitted to be unsatisfied with the alterations and 11 said the costs were higher than expected.

Most respondents would like to have all of the evaluated rooms enlarged and believe storage space to be insufficient, especially in the living room. Windows and doors are blocked while trying to fit basic storage furniture along with beds and other furniture, making these less ergonomic or even preventing residents to regularly open their windows.

With question “3. What new demands have arisen on the home with COVID-19?” we observed that 14 out of 20 respondents spent most of their time at home (more than 18 hours a day), and 7 out of 20 had the time spent at home increased in 7 hours or more after the pandemics. Hence the

spaces at home became more occupied. Of the 20 respondents, 8 spent more time in the kitchen, 6 worked remotely from home, 5 were starting new businesses and 7 were educating the children at home - activities imposed by pandemic's social isolation measures.



SCHEMATIC PLAN - HOUSE C245
NO SCALE



NUMBER OF RESIDENTS: 7
ENLARGMENT PATTERN: side and back
CREATED ROOMS: outbuilding, kitchen and laundry
RENOVATION STATUS: unfinished
MATERIALS IN THE RENOVATED/EXTENDED AREAS: walls - ceramic brick; cover - fiber cement; openings - in aluminum. It was not possible to verify the materials used in the outbuilding.

FURNITURE CONDITION: standard and in good condition; there are objects outside the wardrobes, but the furniture does not interfere with circulation. It was not possible to verify the furniture of the outbuilding.
CONDITION OF WINDOWS AND DOORS: all environments have full openings. It was not possible to verify the doors and windows of the outbuilding.

ENLARGEMENTS AND INTERVENTIONS
ORIGINAL HOME

Figure 6 Example of a floor plan developed for analysis purposes.

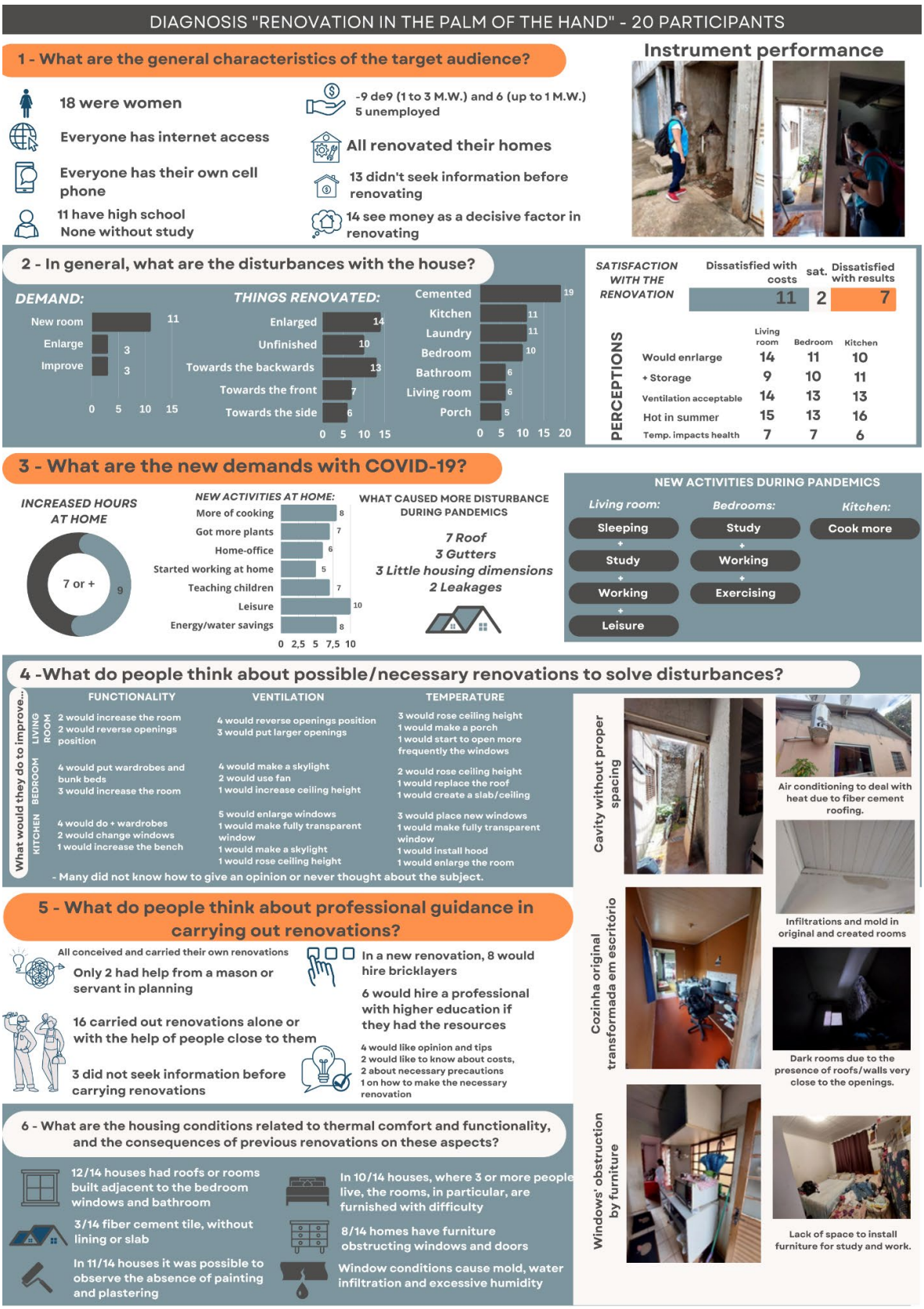


Figure 7 Summary of the results of the survey.

The living room and the kitchen were the most occupied rooms, though kitchen occupation was due only to an increase in cooking hours. The living room were employed in new ways such as for sleeping, studying, working or even having children's dance classes.

Working and studying in bedrooms also increased. Complaints about the living room referred mainly to its small space and lack of illumination or ventilation. In the bedrooms the primary problems were the lack of space to store work and study items, followed by the lack of space to arrange work and study furniture. Some residents have also complained about the lack of natural light in the rooms which turns it unsuitable for studying. In fact, 13 out of 14 respondents-built additions to the back of the house creating contiguous balconies or not observing the adequate distance between the original house and the addition that would allow enough light and natural

ventilation in the rooms.



Figure 8 A completely cemented land lot and the finishing degree of additions.

When asked about what were the biggest problems with the house during pandemics, 10 out of 19 respondents referred to issues involving the roof and gutters. Along with enclosed rooms due to additions that were too close or even stick to the original building, it was observed the presence of mold and infiltrations in several houses.

Regarding question "4. What do people think about making possible/necessary alterations to solve inconveniences While facing problems in the house and nuisances enhanced during the pandemic, some residents have tried to take action by changing tiles, installing flashings and gutters or covering leaks. Few others have expanded existing rooms or even changed its use.

In order to improve functionality, built-in/bespoke cabinets were suggested, as well as changing the position of openings and undoing previously created rooms that disrupted circulation in the house.

Several residents pointed out that increasing the ceiling height, expanding the rooms and increasing the size of the windows would help to improve ventilation and temperature. Some have indicated skylights to improve lighting and using fan and air conditioning as the only options to deal with stuffiness and heat.

Two of the houses had light well meeting the concern to ensure wholesome bedrooms. In one of them, however, it was noticed that the distance between the walls was inappropriate, the floor had not an adequate slope and there were no flashings and gutters, which causes water to leak from the windows and door when it rains. In another house, the original kitchen was turned into an office to meet the needs imposed by the pandemic, the roof was entirely replaced by fiber cement tiles to stop leaks and an air conditioner was installed in the living room/office to mitigate heat, which according to the resident has already affected the energy bill (photographs are combined in Figure 7).

The answers to question “5. What do people think about professional guidance on alteration projects?” the answers show that no technical assistance is being provided to residents. 20 out of 20 respondents planned their alterations themselves and 2 of them had the help of a mason or construction helper. All respondents made alterations but only 6 of them hired somebody to work on in. It shows these alterations are mostly done by people with no experience, compromising safety and the management of resources and expectations.

When questioned which professionals they would hire, 8 out of 20 people answered a builder 3 people said they would not hire for financial difficulties and 6 people would hire all the available options (architects, engineers, designers, masons and etc.) if they had the resources to do so. As observed, these people have decided to make the alterations themselves or hire cheap services because of financial issues. And it frequently leads to losses due to poor quality services, materials or techniques and discontentment with the results.

When asked what kind of information they would like to get before making alterations, some respondents could not answer. Many would like to know whether their ideas might work and what would be the interferences and interactions with the existing building, while others would like to have information about costs to know how much must be invested. Some people worried about which precautions to take. The answers also included information about how to do, who to hire and how to furnish.

Finally, the answer for question “6. In terms of thermal comfort and functionality, what are the house conditions and what are the consequences of previous alterations on these aspects?” was particularly observed through technical analysis and the design of floor plans that compiles the information about each visited house. We made some remarkable observations that summarize several of the problems already reported in the survey.

Regarding the impacts of additions, 12 out of 14 houses had roofs or rooms built in stick to the windows of bedrooms and bathrooms in the back of the house. It increases problems such as difficulty to study and work, high humidity, mold, and even excessive heat or cold in the rooms.

Regarding the choice of building materials, only 1 out of 14 houses used ceramic tiles in the additions, the others used fiber-cement tile and with no lining or slab. This type of roof tile does not insulate against heat, which justifies the perception of heat and cold by the residents. As for the walls, in 11 out of 14 houses had no painting or plaster. Without any finishes, the walls are exposed to weather and its thermal performance is worse: the heat transfer increases, reducing thermal comfort.

10 out of 14 houses with 3 or more residents reported difficulty using the bedrooms. Sometimes it lacks space for storage and sometimes for circulation. Only 1 out of 14 houses had bespoke furniture and according to the resident — an elderly woman — they turned out to be too high threatening her safety. Other houses had common furniture in a higher number than that provided for in the minimum projects, occupying spaces intended for circulation. In 8 out of 14 houses there were furniture obstructing windows and doors, putting at ergonomic risk its residents and also compromising the light and air circulation in the house.

This analysis supported the selection and the approach of the main problems to be addressed by the application and digital booklets which aim to increase thermal comfort and functionality. Keeping in mind the financial limitations that are characteristic of SH and some improvements suggested by the residents, we recommended strategies that combine lower investment and easy execution. Some of the options for problems with lighting and ventilation, for example, require more financial planning. They are described in the preparation of the guiding materials, on the following section.

4.2 A proposal of the prototype web application structure and its solutions for each problem

The application’s main goal is to promote better quality of life for socially vulnerable people in the context of Covid-19 pandemic. The evaluated data offered evidence based on the reality of residents of PMCMV-SH which substantiated the practical solutions suggested for increasing functionality and thermal comfort in horizontal PMCMV-SH. The solutions will be available for the target audience — residents, service providers, architects and urban planners interested in building and altering SH — through the prototype web application.

Thus, this application might benefit the field of Architecture and Urban Planning with its solutions. It advertises the role of architects and urban planners as promoters of well-being and quality of life to the general public, despite their

income level. It also extends the knowledge of the best practices of building new SH (new projects and alterations) while considering functional and environmental need. Besides, it is an instrument for professional architects and urban planners to provide TASH services through reliable research material and references based on the analysis and understanding of contemporary challenges. Finally, it shows how important CAU-BR and CAU-MG are for orienting and improving architecture and Urban Planning work as well as defending society's interests and safety as a whole.

In such context, the relevance of user-centered design (UCD) is evident as it makes the users the center of the process. User-centered design understands users' behaviors, habits, motivations and expectations, as stated by Hassenzahl *et al.* (2010). According to Vasconcelos *et al.* (2021), to ensure the solutions will be effective and satisfactory and to reduce the risks of an unsuccessful project is necessary to consider the users social practices, preferences and emotional needs.

Life quality is connected to an adequate housing, that suffices the different needs and contexts of families (Rosa and Victorio, 2018; Cardoso and Santo Amore, 2018, Amiratti, 2019; Veira and Bastos, 2022) and these needs lead to self-build. Taking this into account Cardoso and Santo Amore (2018) and Pereira and Paula (2018) remark the importance of Brazilian Federal Law no. 11.888/2008 on Technical Assistance. The law was approved in 2018, assuring free building and altering services for low-income families and social housing.

The MORA group has been approaching these issues through doctorate and master's works and other studies about resilience attributes. Therefore, the prototype web application is developed in the context of the ongoing research [RESILIENT HOUSE].

The prototype application provides recommendations to boost social housing and promote improvements in houses, considering the important relationship between UCD and TASH The proposal focus on hydraulic and sanitary installations, building pathologies, thermal comfort (ventilation and lighting), and environmental quality to complement/aid pandemic's control measures.

The identified issues were divided into two larger themes for analysis: comfort and functionality (Figure 9). In regard to comfort, there are issues with mold and excessive humidity. Also, the attachment of additions in existing rooms block windows and prevent natural lighting and ventilation, and together with the low fiber cement roofs they cause rooms to be too cold or too hot and to lack acoustic privacy.

Regarding functionality, we highlight the difficulty in adapting the rooms — especially the bedroom and living room — to study and work; problems with storage in the various rooms of the house and with food preparation in the kitchen; very large rooms or low roofs created with additions, structural shocks (caused in the self-supporting structures), electrical overload and water flow to the new built environments, dispersed and crowded furniture compromising circulation and functionality, also impacting on aesthetic perception, lack of privacy among residents and difficulty in isolating patients sick with COVID-19.

A table was created with the origin of the experienced problem; its detailing, i.e., the cause of the problem, the negative or perceived effect; the detailing of the negative effect; the call to the application by answering the question "what do you need to solve today?", the detailing of the call, the relationship with health and with COVID-19, the goal of the project in order to solve the problem, what to check, and the detailing of what to check (Figure 10). These aspects outlined several reflections and guided the choice of problems that will be approached by the prototype web application.

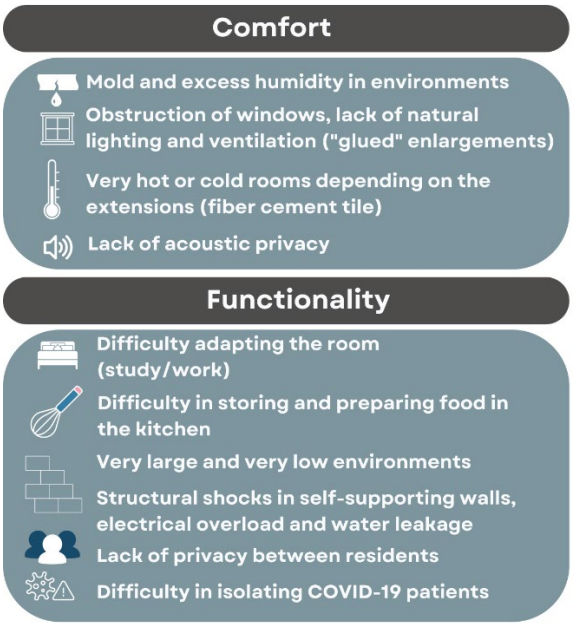


Figure 9 Issues concerning thermal comfort and functionality items.

The problems listed for the development of the content in the first stage were: Problems with the roof (fixing leaks and stopping infiltrations); Problems with humidity (excessive humidity of air and moisture stains on walls and floors); Enlarging my house (ideal size, safe structure for additions, supplying electricity, supplying water and sewage); and studying and working in small spaces (Bedroom for 1 person, bedroom for 2 or more people, double bedroom and small living room).

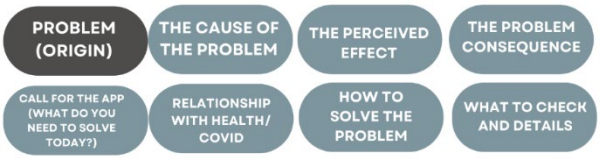


Figure 10 Guiding aspects to the problems listed in the prototype application.

In a second stage, the following content was added: Isolating somebody with COVID-19 (Preparing the room for a healthy person); Cooling or heating my home (lightwell, model, size and position of windows and doors); Choosing the best materials and ventilating and lighting my house (lightwell, model, size and position of windows and doors, choosing the best materials and ventilating and lighting my house); Finally, for the improvement of the prototype web application the following items were added: Storing and preparing food in small spaces: Storing food and utensils and preparing food, furnishing my house: living room, bedroom, kitchen and bathroom, and to stop hearing neighbors through my walls (Figure 11).

This classification was necessary for the selection of primary aspects that will be part of the prototype web application. One of the aspects considered in this selection was recurrent problems such as roofing, need to study and to work in small spaces, humidity, cooling the house, ventilating and lighting and isolating somebody with Covid-19, all shown in Figure 12.



Figure 11 Classification of the problems to be detailed by priority.

An analysis guided the detailing of problems. In each of them there is a subtopic regarding the room or the negative effects. In relation to the “problems with roofing” there are the subtopics: “Fixing leaks” and “Stopping infiltrations”. Considering the “need to study and work in small spaces” there are four needs “Studying/working in a double bedroom”, “Studying/working in a bedroom for 1 person”, “Studying/working in a bedroom for 2 or more people” and ““Studying/working in a living room”.



Figure 12 Organization of the problems.

In “Problems with humidity” we detailed the needs to “decreasing humidity” and “removing moisture stains”. The topic “Cooling my house” advised on the choice of materials, adequate techniques, positioning and shadowing of openings, creating conditions for ventilation and lighting and preparing a room for a healthy person to temporarily isolate people with Covid-19 (Figure 13).

We developed strategies to approach distinct audience segments of users, service providers, architects and urban planners by organizing in each problem a structure to answer the following aspects: 1)”What to check” to guide the diagnosis of the problem that leads to second step; 2) “What to do” to present the solution to the problem (always advising the need to hire an architect); 3) “What do I need” to indicate the equipment needed to solve the problem; 4) “What precautions to take” with parameters to ensure residents and service providers safety; 5) “How much will I spend” with the average costs involved; 6) “Who to hire” indicate the professionals to solve the problem and the need for city council approval; 7) “Impact on health” relate the problem to Covid-19 and other diseases; 8) “References to consult” remarks the important technical standards to delve deeply into the problem’s solution (Figure 14).

To guide the users the contents were organized in an objective way, answering to the topics (what to check; what to do; what do I need; what precautions to take; how much will I spend; who to hire; impact on health and references to consult). As an example of the user journey, we will choose the "problems with the roof" and the subtopic, "fix leaks" describing the problems in detail.



Figure 13 Detailing of the problems.

This topic begins with a brief explanation of what leaks are and how they can damage houses. In the "what to check" tab, there are two tips to locate the leaks: observing the tiles from the inside and throwing water with a hose (Figure 15).

In the "what to do" tab, there are the topics approval, intervention scale, an alert to always consult the owner's

manual delivered by the construction company, to what can be done, the guarantees and about hiring specialized professionals to perform the necessary repairs and services (Figure 16).

The solutions in "what to do" were divided into 5 important points: 1) Poor interlocked or positioned roofs; 2) Holes and cracks in the tiles; 3) Absent or incorrectly installed gutters; 4) Absent or incorrectly installed of flashings and 5) Wood/structure wear (Figure 17).

PROBLEM DETAILS	PURPOSE
WHAT TO CHECK	In this item, an attempt was made to diagnose the problem.
WHAT TO DO	Presentation of the solution to the problem.
WHAT IS NEEDED	Instrumentation needed to solve the problem.
WHAT PRECAUTIONS TO TAKE	Brings parameters to guarantee security.
HOW MUCH WILL I SPEND	Describe average costs involved.
WHO TO HIRE	List of professionals and the need for approval at the city hall.
IMPORTANCE TO HEALTH	Relationship between the problem and the onset of diseases such as COVID-19.
WHICH REFERENCES TO CONSULT	Technical standards for in-depth study in problem solving.

Figure 14 Detailing of the problem and goals.



Figure 15 "What to check" tab.



Figure 16 "What to do" tab.



Figure 17 Five aspects to analyze in leaks.

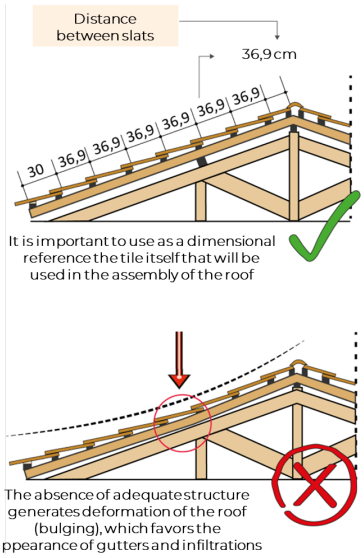


Figure 18 The importance of an adequate structure.

Inside the tab "Wood/structure wear", for example, the correct distance between the slats and the absence of an adequate structure was illustrated (Figure 18), so the users can better understand the prototype web application. For each item, we schematically illustrated to the users both the resolution of the problems and what precautions to take. In the tab “What do I need” the necessary materials, tools and equipment were listed (Figure 19).

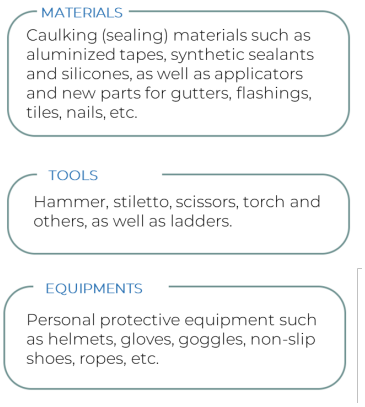


Figure 19 "What will I need" tab.

In the "what precautions to take" tab, 6 important aspects were listed: 1) Clean the surface before redoing repairs (Figure 20); 2) Beware of heat asphalt prepared roofing; 3) Be careful not to fall off the roof; 4) Do not carry out repairs on the roof on humid days; 5) Avoid walking on the tiles and 6) Hire a professional to better invest your resources.



Figure 20 "What precautions to take" tab.



Figure 21 "How much will I spend" tab.

In the "How much will I spend" tab, there is a warning of cost variance (Figure 21) and a table with average values of the materials used to fix leaks.

In the item "who to hire", we highlight Law no. 11.888 of 2008 and the importance of looking for a professional architect and urban planner. By clicking on the "Find an architect" button (Figure 22), the user is directed to the search field for regional architects of the page of the Council of Architecture and Urban Planning (CAU-BR).

The development of the solutions considered primarily the most recurrent and uncomfortable problems to users, but also aims to increase the functionality and thermal comfort of horizontal SH of the MCMV program. "Impact on health" is a fundamental item detailed in all problems for its relevance in promoting better living conditions for socially vulnerable communities. In this item we report problems triggered by diseases and the relationship with COVID-19, reinforcing the relevance of proposals aimed at improving social housing.

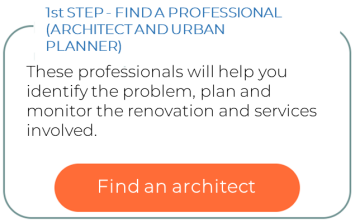


Figure 22 "Who to hire" tab.

Finally, the tab "References to consult" shows the technical standards related to the problem to better detail it. (Figures 23 and 24). For more information, there is a QR CODE and the link "http://reformacasa.facom.ufu.br/home.php".

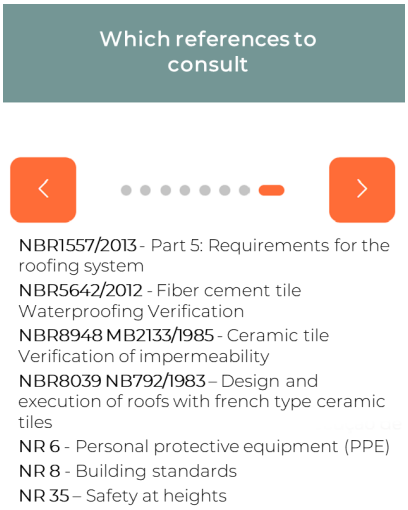


Figure 23 "References to consult" tab.



Figure 24 QR CODE and link "Want to know more about how to stop infiltrations?"

The prototype web application also promotes a continuous understanding of users' demands. It has a permanent evaluative character and for this reason there is a "Tell us your problem" tab in which the user can present his problems and difficulties with alterations (Figure 25) and provide feedback on how useful the information is and if there is another problem regarding the item they are browsing (Figure 26).

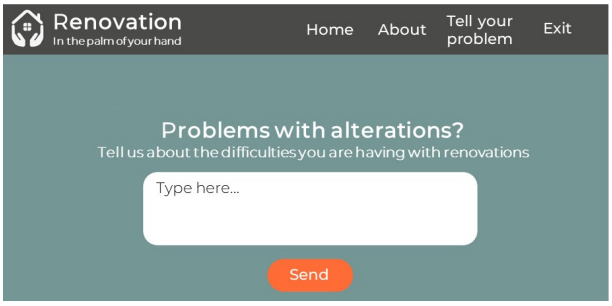


Figure 25 Information field for problems with alterations.

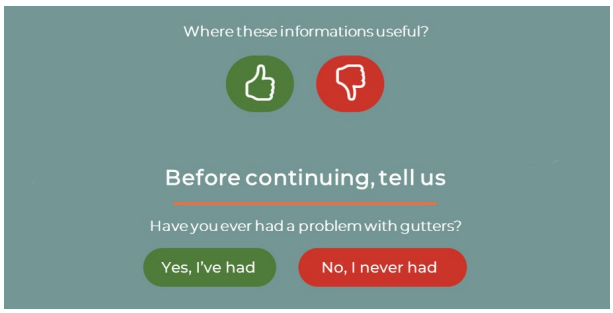


Figure 26 Information field for other problems.

4.3 Usability testing

Nielsen (1994) defines usability as "quality attribute that evaluates the ease of use of an interface," or "the measure of quality of a user's experience when interacting with a product or system." For Zandoná (2017), it is about "ethnographic techniques in which users interact with a product or system, under controlled conditions, to perform a task, with defined objectives, in a given scenario, aiming at the collection of behavioral data, with the main objective of improving the ease of use of the product/system".

Nielsen (1994) also considers the potential financial savings of doing usability tests since product conception, showing how user experience is an important source of information for improvements. There are 5 attributes for the analysis of a product: learning capacity, efficiency, memorizing, errors and satisfaction.

Before promoting the prototype web application, we ran usability tests to identify the necessary adjustments according to typical users. Based on the reported methodology, the attributes to be evaluated were listed according to the structure and browsing flow proposed for the Application, testing its design, learning curve, critical incidents and how functional, intuitive and practical it is. The test is structured into two parts: a form for participants and a form for researchers The main goal is to test how easy it is to use the interface through browsing its contents.

The test asks the participants to perform a given task and right after answer the questions on the form. The task is divided into two phases: 1 - signing up to log into the prototype web application and 2 - to choose a problem/item to browse in and recognize the available contents. We observed participants selected the problem/item according to their personal interests and needs. The most clicked were “problems with the roof” and “problems with humidity”

In parallel, the forms for analysts gathered information about user experience with the interface from their perspectives. It completed the evaluation with specific information concerning the product and possible aspects to improve from the point of view of a researcher who is familiar with the interface.

The test to evaluate the usability of the prototype web application (combining the participants and analysts form) was given by the team to 10 residents who volunteered among the project participants. Figure 27 illustrates the application process and compile the results.

There were mostly positive evaluations to functionality, design, learning and how practical and intuitive the application was. There was some difficulty with the registration of e-mail and password, the access to the contents of the drop-down menus that were "hidden" within the items "what to check" and "what to do", in going to the next pages and, occasionally with the technical vocabulary.

Some critical incidents were observed a few times by the analysts. In one case the participant was unable to complete the task according to instructions because she was unable to move from one page to another, which prevented her from understanding the structure of the content. This was solved by increasing the arrow icons and the width of the slider to make it clearer, placing the most discernible figures in the contents and making the swipe button below do not redirect to the top of the page but to the place the user was browsing.

Two other participants suggested inserting a section where users could enter their demands and receive more targeted guidance from specialized professionals. The "tell us your problem" tab was created in the upper main menu to partially meet this suggestion on the one hand and to collect of more information to support the guiding of alterations, on the other.

There were other suggestions for improvement, in addition to observations from the analysts/researchers regarding other possible improvements, namely:

- separate *onboardings* for each different user profile (architects and urban planners or residents);
- direct information for training of the architect, urban planner or service provider and for the use of residents on alterations;
- the possibility of residents, architects, urban planners or service providers to have their own profiles editing permissions;
- a search tool to guide problem solving.

This information is fruitful to continue the ongoing research [RESILIENT HOUSE] which includes the development and improvement of the prototype web application and of the booklet for the project "Renovations in the palm of your hand" (Villa and Júnior, 2024).

5 DISCUSSION

We observe from the results that the Application has achieved its main goal of providing a set of practical solutions through a web application (tested as a pilot) and available in http://reformacasa.facom.ufu.br/index.php. The information provided with the application aims to guide alterations that increase the functionality and thermal comfort of Horizontal Social housing (single-storey houses) of the Minha Casa Minha Vida program, considering as they are aspects of housing especially impacted by the COVID-19 pandemic. This information provides support for healthier and more resilient social housing.

5.1 Through the prototype web application

The prototype web application was developed as an innovative method of practices and techniques of TASH. It is based on the evaluation and understanding of the impacts on functionality and thermal comfort of SH caused by the life adjustments to COVID-19 pandemics in the 20 houses studied. Based on the well-known methodology Design Science Research that recommend 5 work stages, we employed the evaluation instrument entitled "impact questionnaire" to evaluate and monitor the perception and level of discomfort caused by the COVID-19 pandemic on the functionality and thermal comfort aspects of the SHs evaluated.

The data provided evidence supported by the reality of the users/residents of HIS of the MCMV program. It is noteworthy that this case study has been the focus of the research group [MORA] since 2016, specially in relation to the issue of resilience. The subdivision has had its physical, urbanistic, environmental and social conditions extensively evaluated through extension projects and postgraduate research, as previously reported. The studies of Bortoli and Villa (2020), Parreira (2019) and Araújo and Villa (2020) are relevant for the present work. Bortoli and Villa (2020) characterize the low

thermal comfort of the housing units (UH) of its case study that are derived from conditions inherent to the project and its execution as well as from interventions carried out by the residents themselves without technical assistance.

The use of construction materials with performance below the recommended for bioclimatic zone 4, in which the city of Uberlândia is located, along with the construction of new rooms that often obstruct openings contribute to more than half of the residents evaluating their homes as hot and stuffy and depending on the use of mechanic devices to attenuate the thermal sensation.

Parreira (2019) found the construction system in load-bearing masonry and the reduced dimensions of the UH environments restrict the possibilities of spatial remodeling to accommodate uses different of those for which they were initially thought, compromising their flexibility.

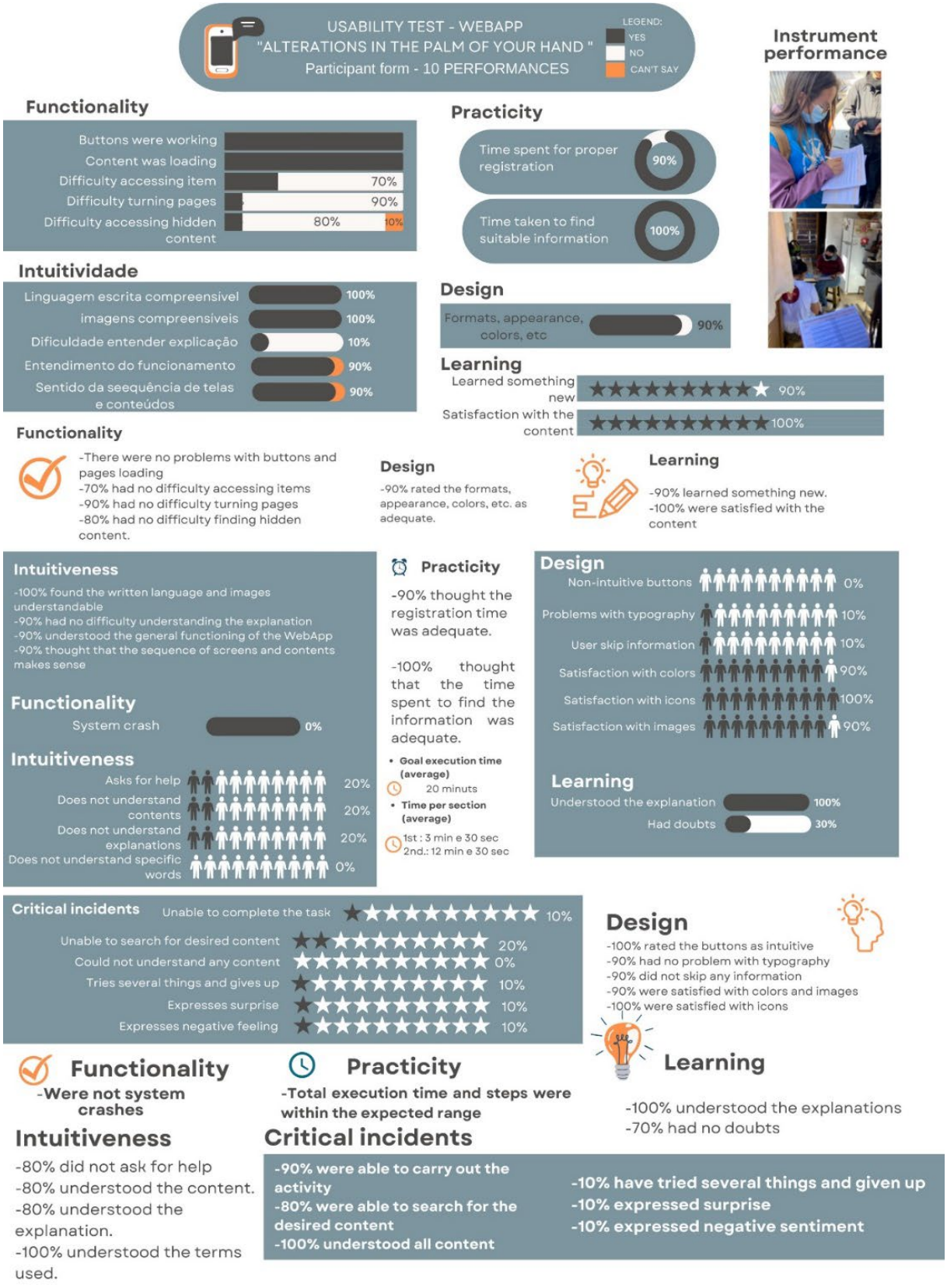


Figure 27 Application process and synthesis of the results for the usability test - Information field for problems with reform

Finally, Araújo and Villa (2020) observed a relationship between the characteristics of the built environment of the HIS and the 5 actions that define well-being (to connect, to continue learning, to take knowledge, to be active, and to give). They highlighted as the main obstacles to the proper accomplishment of these actions in the set: the lack of acoustic privacy between units and between rooms of the houses; the small size of the units; the overlapping of uses and low responsiveness of the environments to properly accommodate the uses, the isolation, and lack of urban quality of the set.

With this research it was possible to verify how unprepared the studied houses are to adapt to the physical changes demanded under normal conditions, indicating among other problems their low functionality and thermal comfort, a symptom of low resilience. With consequences of the pandemic, such as the loss of jobs, reduction of family incomes and thus cohabitation situations as well as the social isolation measures, SH residents has to face the reality of their homes for longer than usual, evidencing and even enhancing existing problems.

In this sense, we remark that potential of the Application to provide a set of practical solutions so that an audience interested in building and altering SH (i. e. residents, architects, urban planners and service providers) can increase the functionality and thermal comfort of the houses.

The Application was initially intended for residents participating in the case study but its impacts were higher than expected. Through virtual sharing it proved to be viable and appropriate for other horizontal SHC of the MCMV program (earning 1 to 3 times minimum wage) as well and the service providers, architects and urban planners, and residents of bioclimatic zone 4 (same as Uberlândia) that were interested in or carrying out alterations.

5.2 Relevance of the Application and why to create TASH content on the internet

The present work contributes to the areas of Architecture and Urban Planning, advertising the importance of the profession of the architects and urban planners as promoter of well-being and quality of life for the population in general, regardless of their income range. It also extends the knowledge of the best practices of building new SH (new projects and alterations) while considering functional and environmental needs. Besides, it is an instrument for professional architects and urban planners to provide TASH services through reliable research material and references based on the analysis and understanding of contemporary challenges.

Finally, it shows how important CAU-BR and CAU-MG are for orienting and improving Architecture and Urban Planning work as well as defending society's interests and safety as a whole. The project directly benefited 20 residents of houses studied by providing a set of practical solutions for carrying out alterations. By providing reliable and widely consulted material for users, service providers and architects and urban planners, it directly and indirectly supports the implementation of reforms capable of adding health and resilience to SH. Hence, it contributes to the fight against the coronavirus and to preserve the physical and psychological integrity of families from social programs throughout the proposed territory (a region delimited by bioclimatic zone 4).

Thereby this work can add to the preservation of the health and well-being of society as a whole. In addition, the availability of solutions through the prototype web application indirectly contributes to the democratization of access to knowledge of the best practices in relation to the design and reform of SH, minimizing the occurrence of negative effects derived from the implementation of interventions without adequate technical assistance.

Finally, we highlight the relevance of the work in order to test the use of web applications, enhancing the access to information in similar populations. To make information available online seems to be an important tool to be tested and improved, since more and more people are gaining access to the internet.

6 CONCLUSION

The studies carried out in the context of the ongoing project "Alterations in the palm of the hand" and the research methods employed in the areas of Architecture and Urban Planning, Design and Computing supported the elaboration of the prototype web application. Through the application of surveys, technical analyses and the study of the target audience using the Post-Occupation Assessment (APO) method, it was possible to identify the problems and needs of the social housing estate residents regarding the realization of alterations, specifically in the pandemic context. The sample allowed information collection that meet the research group's previous perceptions regarding the horizontal dwellings of the MCMV program: the implementation of house x lot disfavors expansions; interventions in social housing without technical assistance resulting in new problems; technical assistance services are not available for residents; thermal comfort and functionality are deficient and have especially compromised the good development of new tasks imposed by social isolation, especially study, work and leisure. The study demonstrates that self-building frequently aggravates the initial conditions of the house, leading to dissatisfaction and an unhealthy house, especially regarding lighting, ventilation, temperature and functionality on its inside.

The results provided some important insights to help dealing with these issues: (i) there is not enough knowledge of construction and many people do not know or do not have the building owner's manual of their own homes; (ii) it is not a resident work to plan or build but they need basic knowledge of construction to be able to communicate their expectations and to understand the process; (iii) the role of the architect in this case is not common knowledge; many residents think that hiring an architect is unfeasible and are unaware of the right to Technical Assistance for Social housing (TASH) guaranteed by Law 11.888/2008; (iv) all residents have access to the internet and to mobile devices for personal use. It was also observed that one of the main needs of the target audience is access to information that effectively explain the variables involved in carrying out alterations and the consequences of self-building without proper professional assistance.

Hence the relevance of the strategies of UX design, UI design and user-centered design to combine such aspects. Thus, this work is a pilot because it seeks to improve the following items: (i) expansion of guiding tools through the advances in the institutional research RESILIENTE HOUSE; (ii) expansion of usability tests to improve communication between website users: residents, architects and urban planners and service providers; and (iii) improvement of the UX design and UI design of the products in order to make them more efficient.

Finally, we would like to emphasize that the platform in question is constantly being improved, notably based on its usability tests with users. In this sense, a new updated version is under development and is expected to be published by mid-2025.

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