

EXPERIENCE REPORT

Using Design Thinking to Break Social Barriers: an Experience Report with Former Inmates

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Abstract

Context/motivation: Design Thinking techniques have been widely used in software requirements elicitation to understand the necessities of stakeholders and end-users. However, there is a lack of evidence of their effectiveness when applied to vulnerable populations. *Question/problem:* What are the implications of using Design Thinking techniques to elicit requirements in a community of former inmates - and what would be the benefits of and challenges in this deployment? *Principal ideas/results:* In this paper, we report our experience of using Design Thinking for Requirements Elicitation of a mobile application, customized for the former inmates of the Brazilian Prison System and their families. *Research methods:* We applied techniques such as Brainstorming, Stakeholder Mapping, Personas Creation, Rapid Ethnography, and Interviews to obtain relevant data and create several prototypes. *Contribution:* These techniques contribute to the development of an uncommon application that aims to help the reintegration process of former inmates into society. Our results validate the initial hypothesis that such techniques, when applied to a sensitive context, assist product development that meets the end-users needs by creating a higher-quality product. *Limitations:* The main limitation of the research was the lack of access to low-literacy end-users and/or former inmates without previous experience using mobile devices.

KEYWORDS:

Design Thinking; Requirements Elicitation; Former Inmates; Interviews; Mobile Application

1 | INTRODUCTION

Some of the problems related to software development are due to an incomplete or ambiguous requirement elicitation, which may result in systems that do not encompass all the essential functionalities for the users of a system, or do not incorporate innovations nor creativity¹.

Despite the techniques and tools provided in the Requirements Engineering's literature^{2,3,4,5,6,7}, there is a constant urge for innovation and creativity, in order to understand the users' needs and the particularities of each system, according to what the users need or request^{1,8}.

Aiming to minimize the perceived requirements elicitation challenges, additional techniques to support this process were also suggested, including the use of creativity techniques and Design Thinking. Design Thinking provides a way to target the user's needs in a more efficient manner^{9,10,11,12,13,14,15,16} and has been widely employed in the elicitation of software requirements.

Although Design Thinking techniques have been used in several scenarios and were deemed effective, there is a lack of research studies detailing the experience of using Design Thinking to identify the requirements for systems that target audiences of users from vulnerable groups—including inmates from developing countries that are often illiterate and demand more specific requirements concerning both privacy and usability, for instance. This lack of understanding brings the general question of our research: *What are the implications of using Design Thinking techniques to elicit requirements in a community of former inmates - and what would be the benefits of and challenges in this deployment?*

There is a difficulty in applying Design Thinking to vulnerable populations, precisely because it deals with the lives of people who are not always willing to participate in the applied techniques or because they present physical/psychological states that may compromise the results, for example. In the hospital setting, several factors can compromise the research, such as: the patient's condition, the need to adapt techniques, or even the duration of the research. In our research involving the former inmates population, there were some difficulties such as the unwillingness of end users to participate in the immersion and empathy phases when raising software requirements.

Also, in some contexts of sensitive settings, there is a need to go through ethical approval processes, and it is important to note that our project was approved by the ethics committee. In short, each of these contexts should be analyzed separately because they present divergent difficulties in the application of the techniques or the study. DT as a creative, empathic, and systemic tool could be used to improve quality of life and emphasize the importance of social inclusion, being efficiently used in software development and/or inclusive design. This research can serve as inspiration for other researchers to apply Design Thinking in contexts with vulnerable populations as a way to support accessibility and equality, narrowing this current gap.

In this paper, we present an experience report on the requirements elicitation of a mobile application to support the reintegration process of former inmates into society, using Design Thinking techniques. Initially, we chose the Service Blueprint method due to the end-users' profile, to better understand the users' days after their release from the penitentiary, and how the app could be a useful service for them in this context. To gather the necessary data, we held meetings with stakeholders and conducted interviews with former inmates and employees of a Physical Social Office located in the state of Espírito Santo, Brazil. Based on the results and considering users' difficulties and needs in their post-prison life, the features of the Virtual Social Office (ESVirtual) were set.

The use of Design Thinking techniques yielded valuable insights into the requirements elicitation stage. In our first meetings with stakeholders, some features were pinpointed. After the interviews with former inmates, we discovered several other functionalities that would otherwise not have been discovered and consequently would not have been implemented in the application. It is worth mentioning that the opposite also happened, i.e., some features were initially planned to be in the app, but during the interviews, we learned that they would not be feasible. Altogether, the results of this study led to several implications.

First, we present how to adapt and select Design Thinking methods to meet the possible needs of the vulnerable population. Second, we present evidence that such tools could be advantageous for a product requirements elicitation targeted towards this population. Finally, we discuss the preliminary test results and how the developed product could have its impacts assessed and analyzed upon subsequent internal releases.

Regarding the interviews with former inmates and Physical Social Offices' employees, our main findings were:

- Social Office employees revealed during the interviews that they find initiatives such as the ESVirtual application are essential to help the reintegration process of former inmates into society. Among the information provided, the employees considered it useful to provide, for example, information about how to prepare for a work interview. Some of the features that were highlighted as very relevant are Documentation, Stories from other former inmates, Useful addresses, Starting over, Professional courses, and Temporary housing.
- In interviews with former inmates, it was possible to realize that, although the application's target audience is highly varied and includes people with low literacy and with little or no experience using mobile applications, the ESVirtual application was able to serve them effectively thanks to, among other factors, its objectivity in presenting information and simplicity in the interactions required for navigation. Moreover, although the application already has several features with real potential to support the reintegration process, there are still several difficulties that the former inmate population and their families face, which could also be addressed through new features in the ESVirtual application. Finally, it was also possible to note that, even though the app shares relevant information with a true support potential, the lack of

dissemination, besides resulting in the lack of knowledge of the service by most of the former inmates of the prison system, also ends up generating distrust in some former inmates who get to know the service through unreliable sources.

- Through the survey, it was possible to identify that the former inmates' greatest need is job opportunities, which is something they are most looking for and would like to obtain through the ESVirtual.

2 | BACKGROUND AND RELATED WORKS

Design Thinking employs both sensibility and design methods to solve problems, targeting the users' needs through a viable and commercially feasible technology¹⁷. Simply put, Design Thinking seeks the dissemination of innovative ways to reason and understand design solutions¹⁷.

The concept suggests a collaborative working approach through the stakeholders and the project team, creating prototypes that are iteratively refined until completion¹⁷. Furthermore, it is human-centered and employs a multi-lateral process of interaction between all project parties, developing empathy between them, thereby contributing to the mitigation of uncertainties in the market, design, and technology¹⁸. Through collaboration and teamwork, team members' individual skills are developed, which, when combined, produces quality work.

Design Thinking enables the conception of innovative possibilities and the development of both creative and diverse thinking. There must be at least two phases in the whole process to execute it: the divergence and convergence phases^{19,20}. The divergence activities are intended to test different alternatives to multiply the options of choice. When testing competing ideas and comparing them with one another, the chances are that the outcome will be bolder, more creative, and more eye-catching. Convergence activities consist of making choices from the existing options related to the respective context. It is the opportunity to critically review and evaluate the ideas generated in the divergence phase in order to select them based on predefined criteria, expanding on the original ideas¹⁹.

There are several Design Thinking models with different stages. The proposed models by Sandino et al.²¹, Hiremath and Sathiyam²² and Coutinho et al.²³ present seven stages. De Paula and Araújo suggested a six-stage Design Thinking model associated with the agile development process and Lean Startup. Newman et al.²⁴ presented DrivingBoard, a 6-phase Design Thinking model that uses Participatory Design and Agile Development. Ximenes et al.²⁵ combined Design Thinking, Lean Startup and Agile Development. The model proposed by Stanford University's D-School consists of 5 consecutive and iterative phases, according to the requirements of each phase's result^{25,26}.

In the context of Software Engineering, Design Thinking provides methodologies for requirements elicitation with a specific focus on users' needs, yielding a series of prototypes that often result in innovative solutions. Thus, different techniques and tools can be employed to help identify significant insights from existing information and find solutions to problems. Among the techniques, we highlight examples such as: Brainstorming, Service Blueprint, Stakeholder Mapping, Persona creation^{27,28}, Rapid Ethnography, Interviews, and Prototyping^{29,30,14}. Below are brief concepts of each technique mentioned:

- Brainstorming - is a technique used to propose solutions to a certain problem, from several ideas, occurs in the ideation phase³¹.
- Service Blueprint - It is a graphic matrix that describes the service delivery processes and maps all the interaction with the company³². It is a process-oriented method that shows all the steps and flows of service delivery³³.
- Stakeholder Mapping - It is a representation of all possible stakeholders in a certain product or service. The interaction between stakeholders can be analyzed and mapped for various purposes³³.
- Personas - Is a technique that consists of creating fictional characters, analyzing the behavior among consumers with extreme profiles, in order to gather characteristics³².
- Rapid Ethnography - Technique that consists in achieving a deep understanding of important activities and artifacts in a short period of time.
- Interviews - Method that seeks through various techniques to obtain information from the interviewee³².
- Prototyping - A stage of DT that designs and allows a visualization of systems and their interactions³¹. It is to transform the abstract to the physical³².

2.1 | Related Works

Rodriguez et al.³⁴ investigated how Design Thinking teachings influence the marginalized students' identification within computer, electrical, and software engineering programs. The results showed that marginalized students developed an identity with the surveyed courses, showing greater interest and performance. The authors concluded that the Design Thinking teachings were crucial to the students' engagement in these courses. Moreover, the work of Cysneiros³⁵ is presented in the healthcare scenario, where there are several limitations when it comes to the elicitation of requirements due to dealing with people's lives, who are not always available or due to the elicitation techniques' restrictions. Therefore, their work aims to present the techniques and their adaptations, when necessary, to apply them in selected hospitals in Brazil and Canada.

The work "Child's play: using techniques developed to elicit requirements from children with adults" by Millard et al.³⁶ uses case studies to elicit requirements that are the basis for future development of technologies for children and the goal of their study is to prove that these tools can be used to obtain requirements from adults. The authors use the techniques of scenarios, roleplaying, and storyboarding for requirements elicitation and point out that one of the downsides is the production of impractical scenarios.

Canedo et al.³¹ investigated which techniques and tools to elicit requirements are most frequently employed in both the literature and the industry. The results showed that the most used techniques were Interviews, Brainstorming, and Prototyping. However, the authors do not present the challenges encountered in applying DT or suggestions for overcoming those in real contexts.

Valença³⁷ proposed a process called "Creaditivity", which consists of a set of both creativity and Design Thinking techniques to elicit requirements. The assessments' results were positive, so most participants stated that the process had good usability and potential to add value in the search and solution of problems. However, the authors mention that the process has not been evaluated by experts, nor tested in large companies.

The work proposed by Lichtenthaler³⁸ drew a parallel between Design Thinking and Lean Startup as a way to increase the innovation process agility. The authors concluded that the combined use of Design Thinking and Lean Startup generated a series of benefits in the organization, including identifying, evaluating, optimizing ideas and opportunities, and the rapid development, implementation, and introduction of products to the market. Lichtenthaler³⁸ states that focusing only on Lean Startup and Design Thinking will typically not allow companies to fully utilize agile innovation, suggesting that companies should use both approaches together.

Hehn et al.³⁹ researched the application of Design Thinking methods in Requirements Engineering processes. The results showed that their use supported the software development team in the elicitation and requirements analysis phases. Besides, the techniques used in Design Thinking fulfilled the needs of both stakeholders and software end-users. The authors state that it is an essential but overdue discussion, making the need for further research clear.

Paula et al.⁴⁰ investigated the use of Design Thinking and concluded that the concept has been gaining strength in the software industry by encompassing approaches focused on understanding users' needs. The authors also identified that the empathy phase is primarily used during the requirements elicitation activity, creating innovative products by using creativity as a principle for innovation. In contrast, the authors mentioned the difficulty in generating original ideas and the consequences of having to address the project's cost and time planning, rather than the user's needs, during the decision-making process. However, the authors mention that the process has not been evaluated by experts nor tested in large companies.

Souza et al.¹⁴ developed the Design Thinking Assistant for Requirements Elicitation (DTA4RE), a tool that recommends Design Thinking techniques to support the requirements elicitation process. The tool can be used by industry professionals willing to adopt Design Thinking methods during software development. DTA4RE consists of a collection containing 27 techniques that can be suggested to the user through a recommendation questionnaire and a repository with support material for the application of these techniques. The authors concluded that the tool helped in the selection and learning of the Design Thinking techniques and the techniques suggested by it were useful when applied to real projects.

Filho et al.⁴¹ conducted an exploratory study to investigate how Design Thinking benefits the development of a data-driven requirements elicitation tool to extract user assessments from a mobile application and subsequently analyze and summarize the results. The authors concluded that Design Thinking techniques enable a better understanding of the problem and satisfactorily support the development of user-centered solutions. From the outcome of this study, the authors claim to be developing the Mining Reviews tool and are planning to analyze the benefits of other DT techniques and evaluate the usefulness of the techniques in the industry.

Duarte et al.⁴² investigated the use of Design Thinking integrated with Software Engineering, along with the use of scenarios to discover user needs and the characteristics needed for the development of a software system. The authors employed user

journey map, service blueprint, storyboard, and storytelling to specify the scenarios. The authors concluded that using these techniques facilitated the understanding and identification of the users' needs since they helped in the users' familiarization and provided better communication between the system's stakeholders. However, despite proving that it can be used to understand requirements better, the study was only applied across Uber rides, making the need to explore the scenarios and techniques further.

Parizi et al.⁴³ proposed Helius, a system that helps decision-making based on the experience and evaluations of professionals regarding the use of Design Thinking techniques. The authors evaluated the proposed tool against existing ones and concluded that Helius innovates by considering the professionals' collaborations when feeding the recommendation algorithms. Helius recommends the Design Thinking techniques according to the number of uses of each of them and/or by the number of positive evaluations they receive. They do not, however, include recommendation algorithms that consider user profiles.

In the related works, it is possible to observe that Design Thinking was critical, even if applied in different phases and ways, towards the outcomes of the mentioned works. Most authors, if not all, stated that the design thinking techniques employed in their particular contexts supported understanding their problem, supporting the development itself and the development teams and stakeholders. However, some studies and tools are in the early stages of development and should be further developed to be applied in new contexts, scenarios, and techniques.

In contrast to the related works, this study uses Design Thinking techniques in a software development context targeting socially vulnerable end-users who are not always willing to participate in immersion and empathy phases when eliciting software requirements, as happens in existing works in the literature, which developed systems in traditional contexts.

3 | METHOD DESCRIPTION AND STUDY SETTINGS

In our research, one of the main reasons for adopting DT was that it promotes the use of empathy to understand the real problems and needs of the users and helps to propose technological solutions that are suitable. This is especially important because we are aiming to reach a vulnerable population, former inmates.

Therefore, we organized our method as a human-centered iterative process based on the approach proposed by the d.school⁴⁴, one of the most cited DT models in the literature. There are five steps: Empathize, Define, Ideate, Prototype and Test, as shown in Figure 1. The focus of the first one (Empathize) is to gain a deeper understanding of the issues involved in the users' life experiences by interacting with them. The DT techniques used were Brainstorms, Stakeholder Mapping, Personas, Rapid Ethnography and Interviews. Some details are provided in the next section. The second step (Define) is used to synthesize the information gathered to define the core challenges for the research. The DT techniques used in this step were User Journey Map and Service Blueprint. The third step (Ideate) enables the possibility to look at the problem from different perspectives and ideate innovative solution alternatives. The DT technique used was Brainstorms. In the fourth step (Prototype) some physical artifacts are built, in order to get them evaluated in the fifth and final step (Test), when they get refined. The prototypes developed were a paper low-fidelity and two high-fidelity with Marvel and Figma.

Table 1 presents the division of the two studies conducted, with the organization of five Design Thinking model steps according to the previous description, and for each of them, the techniques that were chosen. The table does not show that the final prototype artifact was tested and approved by the CNJ stakeholders and a real implementation application was created. We opted to omit that because these phases are not related to DT.

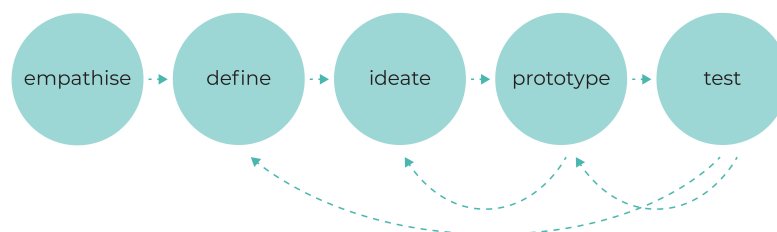


Figure 1 Design Thinking Method divided in 5 steps.

Table 1 Design Thinking Method divided in 5 steps with Techniques used

Studies	Design Thinking Steps	Design Thinking Techniques
First	Empathise	Brainstorms Stakeholder Mapping Personas Rapid Ethnography Interviews
	Define	User Journey Map Service Blueprint
	Ideate	Brainstorms
	Prototype	Low-fidelity prototype with paper High-fidelity with Marvel Design Platform ⁴⁵ and Figma Design Tool ⁴⁶)
Second	Test	Usability Tests and Interviews with Former Inmates Online questionnaire for former inmates Interviews with Physical Social Offices' Employees

3.1 | Settings for the first study: Design Thinking Procedures

In this study, we utilized some Design Thinking techniques intending to understand the users' profiles that compose the app's target audience, their difficulties, and how a mobile application could bring functionalities to assist the former inmates in their reintegration process into society. These techniques, which are listed below, were employed in order to achieve this purpose and/or validate any propositions devised by the app's development team.

- Brainstorming – is a group dynamic method that aims to solve specific problems or develop new ideas for a project. Also known as Idea Storming, Brainstorming is a technique to stimulate the generation of a large number of ideas in a brief period. Often carried out as a group, it is a creative process conducted by a moderator in charge of letting participants feel at ease and stimulating creativity without letting the group lose focus¹⁴.
- Stakeholder Mapping – is a visual or physical depiction of all stakeholders involved in a given service. With the mapping of this audience, it is possible to analyze and chart their activities, in order to understand how they relate and interact with one another, besides what their interests and motivations are²⁷.
- Personas – Personas are fictional characters designed to depict groups of potential users of the service being developed. The creation of these Personas is often done through insights gathered by using techniques such as Stakeholder Mapping and Interviews. The purpose of creating Personas is to focus on building the system for real people with real needs, rather than abstract demographic data^{27,28}.
- Rapid Ethnography – is the execution of short-term observations in order to provide general information about the context of the project and advise what the software's scope should be. It allows a rapid and in-depth comprehension of the requirements, cognitive and environmental constraints, cultural constraints, norms, practices and customs, biases, and behaviors associated with the use of a given technology⁴⁷.
- Interviews – is a technique that aims, in a conversation with the interviewee, to obtain information through questions. They are conducted in person so that personal expression and body language characteristics are perceived within the interview. However, they can also be conducted remotely over the phone or via video conference. Interviews are particularly beneficial when the story behind the interviewee's life experiences is desired and the questions asked during interviews vary according to the nature of what one wants to discover⁴⁸.

The Service Blueprint and User Journey Map techniques were employed to perform the data synthesis. During the implementation phase, we used a prototyping strategy, including the following procedures.

- Service Blueprint – is an operational technique that describes some service's nature and characteristics in sufficient detail to verify, implement and maintain it. Also, it is a graphical technique that displays the functions of the process in which all

the points of contact and processes from the initial phase of the project are documented and aligned with the experience of the end-users. It allows clarifying which parts of the system are visible to the user, i.e., where their perceptions about the effectiveness of the service will be formulated to ensure the delivery of high-quality services⁴⁹.

- User Journey Map – is a graphical representation of the user's relationship steps towards a product or service, which describes the main steps taken before, during, and after using the software. The method tells a story about an individual's actions, feelings, perceptions, and state of mind, including positive, negative, and neutral, as one interacts with a given product or service over a period of time⁴⁸.
- Prototyping – is the tangible creation of artifacts at various resolution layers to develop and test ideas across project teams, stakeholders, and end-users. Prototypes are defined by their level of faithfulness. Low-fidelity prototypes fulfill an internal development purpose as a checkpoint for the team, whereby the product is seen as a proposed concept for constructive review and timely feedback for iterative changes. An example is a paper prototype, in which users are presented with drafts representing screenshots of the interface to depict what each page would do. High-fidelity prototypes are more refined, often representing the final product's appearance in detail and sometimes even its basic functionality, such as an interactive prototype capable of providing a real user experience to enable proper feedback⁴⁸. To develop high-fidelity prototypes, we initially used the Marvel Design Platform⁴⁵ and then switched to the Figma Design Tool⁴⁶.

To better understand the needs of our target population, the Brazilian prison system's former inmates, we conducted Brainstorm sessions with the National Council of Justice (CNJ) stakeholders. The stakeholders' roles were to raise the knowledge of the CNJ in relation to the former inmates, perceive their difficulties and how they could get support from the CNJ itself or from other institutions. We also conducted semi-structured interviews with the Physical Social Office employees along with three former inmates. Table 2 presents the Design Thinking techniques used together with both users and project stakeholders. The Brainstorm meetings and Interviews were performed to identify requirements to develop a digital version of the Virtual Social Office (ESVirtual) that could replicate, in a virtual environment, the activities and services performed in Physical Social Offices. The ESVirtual mobile application was conceived to assist this specific population in their reintegration process into society.

Table 2 Design Thinking techniques adopted with both users and stakeholders

Technique	Participants
Brainstorm session and Interview	4 Project Stakeholders from CNJ
Interview (8 questions)	Former Inmate 1
Interview (8 questions)	Former Inmate 2
Interview (8 questions)	Former Inmate 3
Interview (10 questions)	Physical Social Office Employees

Sections 3.1.1, 3.1.2, and 3.1.3 detail the activities developed to identify the application requirements. Sections 4.1.1 and 4.1.2 provide the procedures employed in subsequent design and development stages after resorting to the approach depicted in Section 4.1, which describes the app requirements and the development team's actions to validate the suggested functionalities.

3.1.1 | Brainstorm Sessions

The brainstorm sessions with project stakeholders took place before, during, and after the interviews, allowing us to update our insights in the face of all the new information we obtained from the respondents' answers. In these sessions, we employed the Service Blueprint technique to understand the user's journey upon release from prison, outlining several scenarios simulating the difficulties of the former inmates and which services were available to serve them in each case. Thus, we sought to understand how the relationship of this public with such services was developed. In addition, we also attempted to understand which needs were not yet being met by the Government and which kept the former inmates struggling in their re-socialization process. Finally, the knowledge of the CNJ stakeholders about the services offered free of charge by the state to attend to the population discharged from the prison system was essential to understand the journey of these users. These sessions were held in person

at the CNJ headquarters, located in Brasília, Federal District, where at least three researchers from the University of Brasília (UnB) and at least two project stakeholders were present.

3.1.2 | Interview with former inmates

Regarding the interviews with former inmates, they all followed a semi-structured approach - i.e., we conducted the interview with a few pre-prepared questions but allowed the conversation to continue according to the received information, which caused each interviewee to receive unique questions according to the information they had shared. The questions that took part in all those interviews were:

1. Based on your experience, do you think former inmates usually have easy access to the Internet?
2. According to your understanding, what are the greatest challenges in the reintegration process of a former inmate into society?
3. Do you believe it would be important for the application to bring information such as job opportunities and support for people suffering from alcohol or other substance addiction issues?
4. According to your experience, do former inmates take an interest in attending Youth and Adult Education (YAE) courses?
5. Would you disclose your personal data to the application?
6. Where and when do you think it would be best for the former inmate to be aware of the application?
7. Can inmates in the semi-open situation¹ use a mobile phone?
8. Are there any other issues that you believe should be addressed by the application?

Two interviews were conducted through a video conferencing tool, and one was held in person at the former inmate's workplace. At least two researchers and at least one stakeholder were also present at these interviews.

In those, the primary objective was to understand the main challenges they had to face after leaving the prison system and to validate some of the findings we had so far - such as whether former inmates had difficulty in accessing the Internet, and whether information regarding the treatment of alcohol and other substance abuse was relevant. In addition, for the two former inmates that are actively working in institutions that intend to help this population in the reintegration process into society, we also raised questions related to the main obstacles that do or might hinder its success, questions that exceeded our script since they flowed according to the interviewees' report. A concern not included in the script was the potential difficulty the target audience would face in accessing and benefiting from the ESVirtual services, due to the following factors: lack of access to a mobile device, lack of space on the mobile device to download a new application, lack of Internet access, and low or no literacy.

Another functionality of interest to the target audience identified through the interviews was the sharing of stories of other former inmates who, amid adversity, achieved success in the reintegration process into society. We also found that out of the people with criminal cases registered in the Courts of Justice throughout Brazil (except Rio de Janeiro, Rio Grande do Sul, Pará, and Sergipe) in 2015, at least 42.5% of the former inmates returned to the courts by the end of 2019². This recurrence rate is a reflection of the difficulty this population has in their reintegration process into society, after leaving, they are still perceived as a source of danger by society. Thus, the former inmates we interviewed stated that it could be very inspiring to hear stories of people who went through similar situations and managed to follow their paths without the urge to re-commit crimes.

3.1.3 | Interview with the Physical Social Office

The interview with the employees of the Espírito Santo Physical Social Office was also conducted through a video conferencing tool, with the involvement of three researchers and two of the project's stakeholders. As it is a branch with a well-developed working process and has expertise in supporting former inmates physically, we selected this Office to interview. The following questions were raised in this interview:

¹The semi-open regime works as an intermediary between prison (closed regime) and freedom (open regime), fulfilling the important function of providing the person in prison with the experience of reaping rewards through licit work - by means of working outside through the day and returning to the prison each night - a determining factor for an effective reintegration process into society⁵⁰.

²<https://www.conjur.com.br/dl/panorama-reentradas-sistema.pdf> – Re-Entry and Infraction Reiteration: A look at the Brazilian socio-educational and prison systems

1. Which services does the office provide for former inmates?
2. What are the most frequent requests from former inmates when they seek the Physical Social Office?
3. Does the office have any demands from former inmates that it cannot supply?
4. Does the office request personal data for registration or something similar? If so, which data?
5. Do former inmates have any concerns about providing them?
6. In general, do former prisoners display trust in the services the office provides them with?
7. What are the significant challenges for former inmates in finding the information they desire?
8. Do former inmates usually have access to the Internet?
9. If so, which device do they use the most? (computer, mobile phones, etc.)
10. In general, what are the major challenges for former inmates?

During these interviews, we tried to learn precisely which functions the office performed, and consequently, how it could help the population in their challenges regarding the reintegration process into society. Furthermore, we tried to understand what former inmates' significant difficulties existed, their necessities that the office was unable to fulfill, and the most common demands made by them.

3.2 | Settings for the second study: Usability Tests and Interviews with Former Inmates and Physical Social Offices' Employees

The daily life of a former inmate is marked by vulnerabilities that add to those that historically affect marginalized populations. Among them, difficulties in accessing public policies, demands for health, study, housing, employment, and income are some of the vulnerability factors that are aggravated due to the prison background. Thus, providing mechanisms of mediation between former inmates, information that is relevant to them, and services that are indispensable to them may work as a facilitating tool to expand their access to rights, community networks, and social spheres, allowing them more significant opportunities to find answers to their social and personal demands.

Thus, this scenario is favorable to offer, through a technological solution, software that facilitates access to public policies for people who have left the prison system, offering them an agile and inexpensive way to access information and services that contribute to their process of resuming social life in civil liberty. Specifically, this study aims to conduct interviews, usability tests, and questionnaires with the ESVirtual's end-users (former inmates and employees of physical Social Offices) to identify their perception of the application regarding the social reintegration process. The purpose is to collect information to improve the ESVirtual further.

Some hypotheses were then defined: Hypothesis 1: The ESVirtual assists in providing access to public services by people released from the prison system. Hypothesis 2: The ESVirtual is easy to use. Hypothesis 3: The ESVirtual is being used by the end-user community. To fulfill our hypotheses, we used three different data collection instruments, namely: (I) Usability tests and interviews with former inmates; (II) Online questionnaire for former inmates; and (III) Interviews with Physical Social Offices' employees.

3.2.1 | Usability Tests and Interviews with Former Inmates

We performed the usability tests of the ESVirtual app through an observation-based evaluation performed by end-users⁵¹. The testing methodology was defined in 4 steps: 1) Selection and invitation of participants; 2) Definition of goals, metrics, scenarios, tasks, and post-test questions; 3) Execution of usability tests; and 4) Collected data analysis. The tests were conducted remotely, with usability experts and users in different geographic locations, connected through a videoconferencing tool, with screen-sharing capabilities. The primary motivation for this choice was due to the Covid-19 pandemic, which required isolating the population to avoid transmission. The tests made use of the "think-aloud"⁵² approach, which suggests asking users to express their thoughts and opinions while interacting with the application. This strategy allows researchers to observe how the user approaches the interface and what considerations he/she has in mind when using the interface.

The tests were moderated, i. e., they were conducted in the presence of researchers responsible for explaining the tests to the users, clarifying doubts, and asking post-test questions. The decision to use this approach was motivated by the desire to investigate the “rationale” behind the users’ behavior. In addition, we conducted evaluative tests intended to gauge user satisfaction with the ESVirtual application and how well users are managing to use it.

Semi-structured interviews were conducted with the former inmates through a video-conferencing tool. Initially, the former inmates filled out an Informed Consent Form followed by questions related to demographic data, and then specific questions to the former inmates. In total, usability tests and interviews were conducted with ten former inmates. Among them, three were invited by CNJ stakeholders. Employees of Physical Social Offices invited another three interviewees. The remaining four were contacted by the researchers from the University of Brasilia after being shared by previous interviewees. The average interview time was 1 hour and 4 minutes. The results of the usability tests and interviews with the former inmates are presented in Section 4.2.1.

3.2.2 | Online questionnaire for former inmates

An evaluation questionnaire of the ESVirtual application was made available online for former inmates and was available for completion from August 2021 to February 2022. The questionnaire was divided into three steps: 1) Informed Consent Form; 2) Demographic data; 3) Questions related to the usability and usefulness of the application information. Twenty-one responses were collected, and the average time to complete the questionnaire was 12 minutes. The result of the application evaluation is presented in Section 4.2.2.

3.2.3 | Interviews with Physical Social Office employees

A video conferencing tool was used in the interviews with the Physical Social Office employees. The interaction was divided in three parts related to: Informed Consent Form, demographic data and specific questions. Thirty-two Physical Social Office employees were invited to participate in the interviews by the CNJ stakeholders. They work at the office as psychologists, social workers, legal advisors, interns, technicians, and managers. Among them, twelve employees accepted to participate in the semi-structured interviews, with the purpose of understanding their perception of the ESVirtual app and its usefulness. The results of the interviews can be found in Section 4.2.3.

All questionnaire questions and the usability test execution scripts are available in the supplementary material.³

3.3 | Privacy and Security

To guarantee the users’ privacy and their information security, we adopted Software Security strategies — the process of designing, building, and testing software for security⁵³. Since the beginning of the requirements elicitation process, we defined the security requirements with the stakeholders to guarantee the users’ privacy and their information security. Following a Security by Design approach, we decided not to collect or store any sensitive information that could link users with their exposed data.

We applied another approach to ensure security at the code level by using Static Application Security Testing (SAST) tools. In particular, we executed the code analysis with two state-of-the-art tools to detect the incorrect usage of crypto-APIs: *CogniCrypt(SAST)*⁵⁴ and *CryptoGuard*⁵⁵. We did not intentionally need to use any cryptography on the application. Nevertheless, since we developed the app using React Native, a JavaScript framework for writing cross-platform mobile applications⁵⁶, we wanted to ensure that there were no security issues inserted by third-party libraries under the hoods.

To ensure that no sensitive information was leaking from ESVirtual, we also executed an analysis with the FlowDroid, a highly precise static taint analysis for Android applications⁵⁷. According to Grace et al.⁵⁸, even not malicious applications that were carefully programmed may suffer from such leaks, for instance when they incorporate advertisement libraries.

³<https://zenodo.org/record/6414710>

4 | RESULTS

4.1 | Results of the first study

With the information obtained from the brainstorming sessions and interviews held, together with stakeholders, the research and development team established a set of desirable features for the application. The entire list of features elicited is provided in Table 3.

Table 3 Features planned for the app

Feature	Description
Temporary housing	Feature that provides information related to the Shelter Units, such as the Secretary of Social Development, the Specialized Reference Center for Homeless People (POP) ⁴ , the Social Assistance Reference Centers (CRAS) and the Specialized Social Assistance Reference Centers (CREAS).
Food	Provides information related to low-cost popular restaurants.
Routes	Provides information on potential routes to a location by address or name of the establishment provided by the user.
Health	Provides information on Basic Health Units (UBS), Emergency Care Units (UPA), Psychosocial Care Centers (CAPS), and Hospitals. Besides, it supplies textual and video information on which services each of these establishments offer.
Documentation	Provides information regarding the regularization of personal documents.
Legal situation	Provides information concerning a former inmate's legal situation, with restricted access to users who possess an access key for a given former inmate.
Free legal aid	Provides information on how to get free legal aid.
Process constraints	Provides information regarding the terms of the judicial process of a former convict.
Education	Provides information that allows the completion of basic education, high school, and college to the end-user.
Interests and Skills	Provides support to the user who seeks to discover their interests and skills, mostly focused on facilitating their access to the labor market.
Professionalizing courses	Provides access to free-of-charge professionalizing courses with certificate issuance.
Work advice	Provides videos with practical work advice, such as writing résumés and guidelines on how to behave in an interview and at work.
Child custody	Provides information regarding free legal aid, CREAS and Guardianship Councils.
Family services	Provides information regarding CRAS, and CREAS facilities.
Treatment for alcohol and other drugs abuse	Provides information on Alcohol and Drug Psycho-social Care Centers (CAPS AD), Alcoholics Anonymous, and Narcotics Anonymous.
Stories from other former inmates	Provides inspiring stories of former inmates of the Brazilian prison system.
FAQ	Section that provides quick answers to frequently asked questions from former inmates.
Contact with the Social Office	Provides contact information to an existing Physical Social Office in Brazil.
Location Setup	Allows identifying the current location using the mobile phone's automatic location or a manual one by providing the city's name.
Stages of Criminal Rehabilitation	Provides information on the stages of Criminal Rehabilitation.
Free Wi-Fi spots	Provides information about city locations with free access to a Wi-Fi network.

An evaluation and validation stage would still be required, as it would still be needed to ensure that the data was made available for use within the application and that the information would be conveyed in a convenient and accessible format to the end-users.

4.1.1 | Product Prototyping

As stated previously, all features were designed through insights and suggestions that occurred in brainstorm sessions and during interviews, which culminated in Table 3. Throughout the initial phase, we started the prototype development, initially of low-fidelity, done on paper. In the prototype construction, the emphasis was placed on the application navigation over the concern with layout details. Figure 2 displays a low-fidelity prototype that was developed in the project's first stage.

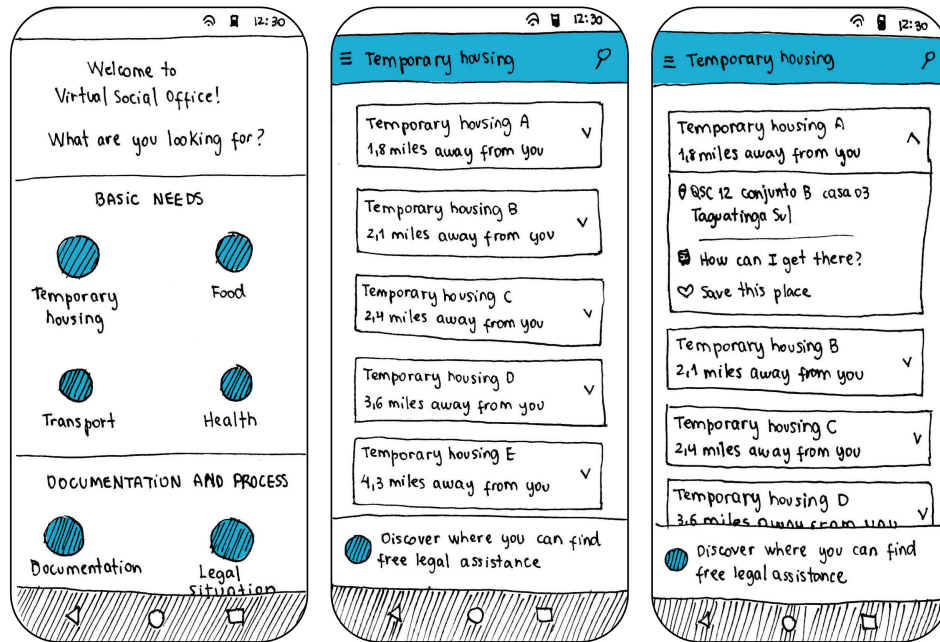


Figure 2 Low-fidelity prototype.

As the team acquired a greater understanding of the app's functionality and navigation, the first high-fidelity prototype was developed using the Marvel Design Platform tool⁴⁵, as shown in Figure 3. Initially, only the Android version was prototyped, in accordance with the layout guidelines defined in the Material Design⁵. The purpose of following these principles was to present the user with a user-friendly and familiar layout. In addition to this, at this time, more significant concern was shown regarding some other layout details, such as color palette and icon content representing each feature. It is also worth mentioning that the icons were still temporary versions collected in the FlatIcon Platform⁶, for internal validation purposes. The final application version was planned to create fully original visual content, allowing the application to be more appealing and providing greater clarity to users with low literacy through clear and meaningful images.

In this model, users can perceive a greater usage of visual elements that represent the functionalities in an attempt to make the application more intuitive and appealing. We also began designing the iOS platform version layout following the Human Interface Guidelines⁷, due to the same reason we have adopted Material Design to build the Android platform application. Figure 4 presents the high-fidelity prototype designed in Figma for the Android prototype.

The low-fidelity prototype goal was to build a fast and effortless model that includes user-friendly features and intuitive navigation, which could serve anyone from users very well-acquainted with mobile applications, to users who had little to no prior experience with it. Whereas the high-fidelity prototype's major purpose was to initiate the development of the app's first version that is both visually accurate and functionally stable, in order to conduct the first usability tests with different profiling users.

⁵<https://material.io/design>

⁶<https://www.flaticon.com>

⁷<https://developer.apple.com/design/human-interface-guidelines/ios/overview/themes/>

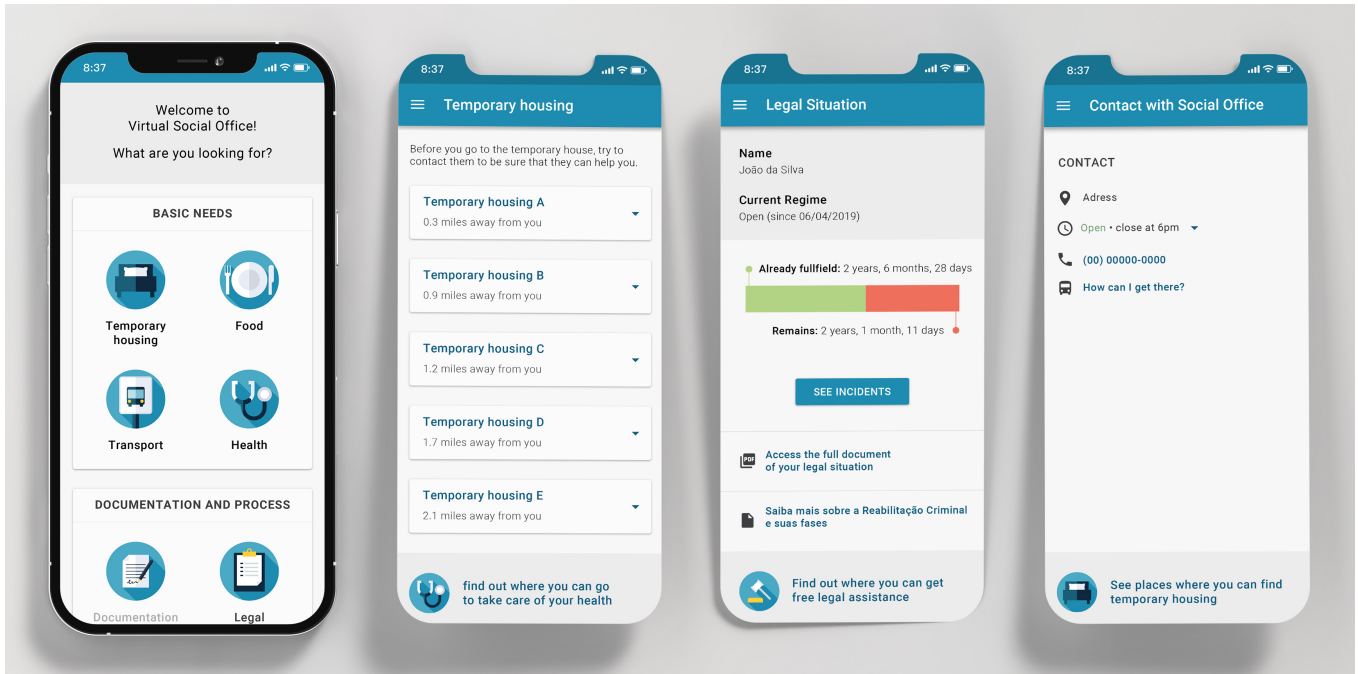


Figure 3 High-fidelity prototype on Marvel Design Platform tool.

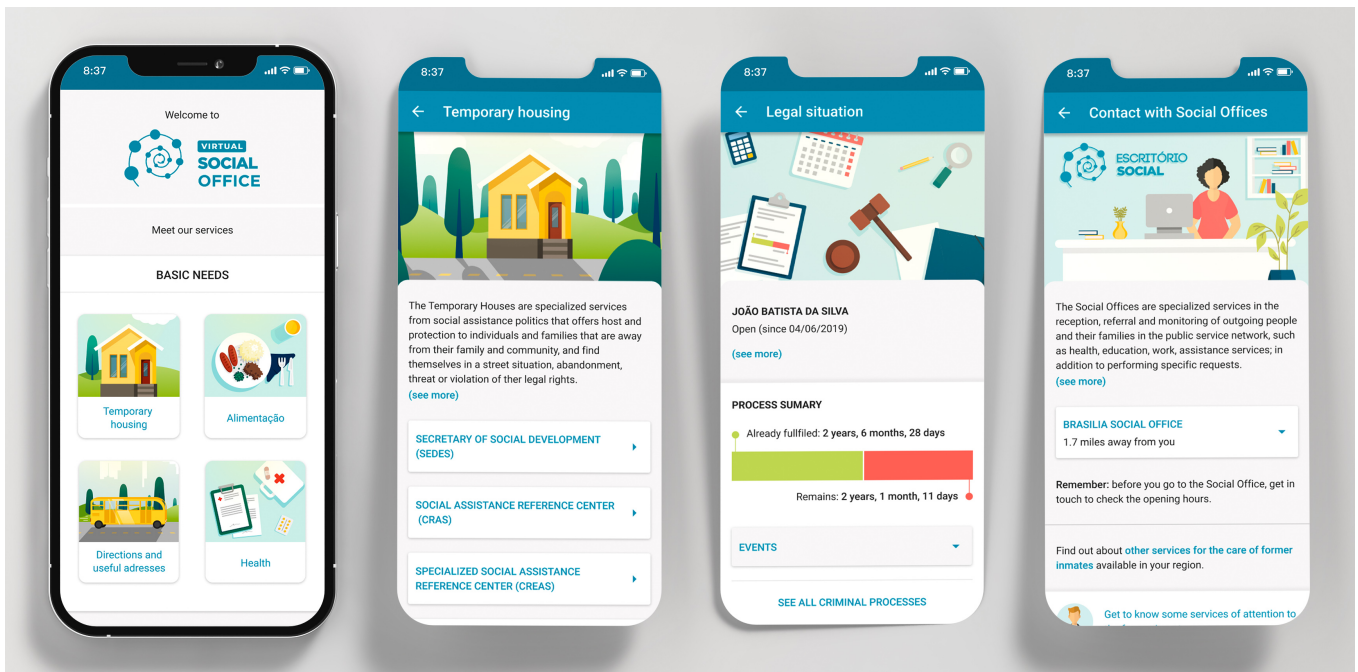


Figure 4 High-fidelity prototype using the Figma Design Tool.

4.1.2 | Usability Tests and Feedback Interview with former interviewees

To ensure the high-fidelity prototyping goals were met, we invited the former inmates who had been interviewed at the project's initial stages to undergo a usability test using the app. In this test, we assigned six tasks. From these, we sought to validate whether the user experience in the usage of the application was smooth and intuitive, and whether the features inserted to date had the potential to be of actual use to the public in question. Using the "think-aloud"⁵² approach, we asked users to express all

their thoughts aloud, providing us with a complete understanding of their experience within the application. In addition, users shared their screens so that we were able to monitor the entire process. The interview script included six questions:

1. Did you feel comfortable sharing your experiences and knowledge during our first interview, in which we focused on the application requirements?
2. Do you believe that your input in the first interview was of value to the ESVirtual application development?
3. Do you believe that interviews with former inmates of the prison system (like yourself) are relevant to the ESVirtual application development?
4. Do you believe we would be able to achieve the same outcome in terms of information obtained from those early interviews without them?
5. Have you identified whether any of your recommendations are included in the application?
6. Based on your own experience with the application usability test, do you have any improvement recommendations for the application?

Through the use of Design Thinking techniques, the team was able to perceive a broad spectrum of necessities arising from the population with previous involvement with Brazilian criminal justice. Thus, it was possible to search for solutions to assist this target audience in addressing their concerns and issues, through the development of the ESVirtual application functionalities.

It is noteworthy that the population coming out of the prison system comprises an extremely diverse range of profiles and necessities. Therefore, not all functionalities present in the application will be useful for all participants. However, it is expected that regardless of their necessity, the app will contain at least one functionality that can be of assistance to them.

In the first sessions in which the brainstorming method discussed in Section 3.1.1 was practiced, before any interviews took place, the stakeholders already had some clarity about potential functionalities for the application, based on former inmates' needs, as it was a topic of interest for their company. This required the validation of the actual need of these functionalities with the end-users, in addition to the viability of providing such information on a transparent and free-of-charge basis to the population.

During the process covered in Section 3.1.2 it became possible to uncover a series of challenges that were, until then, unknown to our application development team. As a case in point, we can highlight the public's difficulty in legalizing their voter registration, which often results in another obstacle in finding a job, given that in the Brazilian context, this document is required to issue a work card and many employers request a citizen's voter registration upon hiring.

We also discovered that, although the creation of a feature that advertised job opportunities for app users was technically feasible, implementation would not be possible since there was not, until then, a source that could provide this service within the application. However, the former inmates emphasized that a commonly neglected necessity is employment advice, such as how to prepare for an interview, from dressing up to behaving. The project stakeholder then partnered with Kroton, a private educational institution that provides elementary school services. Kroton has an online platform that provides a large number of online courses. For the project, the company has offered free-of-charge vocational courses with certification for concluding it. Besides, they created content covering work advice focused on the target audience of the application, a concept conceived in response to the interviewees' desire.

Through the interview process mentioned in Section 3.1.3, we discovered that one of the most common requests of former inmates for the Physical Social Office is the regularization of their voter registration, along with places that provide free legal aid. The former is a demand unable to be fulfilled immediately by the Office, although they can direct the former inmate on the steps needed to achieve such regularization; whereas the latter is more feasible to satisfy. This interview was very successful since it confirmed several of the reports exchanged by the former inmates interviewed.

To ensure an iterative development and provide multiple tests with users, the research and development team decided to release the first version of the application with only some of the features included in Table 3, obtained through the resulting process described in Section 4.1, and proceed with the inclusion of the other features in future releases. The criteria for choosing the features that would be included in the first version were: a) degree of relevance of the features according to the research team's perceptions from the brainstorming sessions and interviews conducted; b) data availability to ensure full development of the functionality.

The prototype was used along with the project's stakeholders to validate both the application's functionalities and wireframe. The usage of such a prototype was of great importance considering that, despite its very simplistic format, the project's stakeholders team was capable of getting for the first time a clear concept of how the application could be presented and, therefore, carry out a more pragmatic analysis regarding the organization of information and functionalities.

To attain the purpose of performing the usability tests, we decided to migrate the whole layout from the Marvel Design Platform tool⁴⁵ to the Figma Design Platform⁴⁶, which provides source code information that simplifies programming, and therefore enhances the development process. The internal team and project stakeholders performed a new prototype assessment within the layout transition phase, which resulted in some layout and content adjustments. Additionally, this version was already assembled with original icons and illustrations, based on the preapproved icons' concept from the previous prototype (Figure 3).

Moreover, this version had already been refined, undergoing several changes in previously foreseen functionalities and excluding those that were unable to be implemented yet, either due to lack of time or lack of information/partnerships needed for its development. The functionalities displayed to the target audience are shown in Table 4.

Table 4 Implemented functionalities within the ESVirtual application for usability testing and interviewing former inmates

Features unchanged as initially foreseen	
Temporary housing	
Food	
Health	
Legal situation	
Professionalizing courses	
Treatment for alcohol and other drugs abuse	
Stories from other former inmates	
Legal situation	
Features with modifications relative to those initially foreseen	
Useful Addresses	The feature's name has been changed from "Routes" to "Useful Addresses" to make the purpose of this feature clearer.
Documents and Benefits	We brought to this feature, besides the information already contained in the old "Documentation" feature, information about social benefits and aids, such as Family Grants, Reclusion Aid, among others.
Start Over	It contains the same information already provided for the "Work advice" functionality. However, the information shared was related to the CNJ's "Start Over" program, which aims to work together with public agencies and civil society to provide jobs and professional training courses for people in prison and former inmates.
Child and Teen Custody	The feature followed with the same information as the "Child custody" feature, but we added the term "Teen" to the title to clarify that this audience is also included in the information shared.
Settings	This functionality allows the user to change application settings, such as allowing or disallowing the application to access their location, as well as decreasing or increasing the maximum radius of establishments (in the case of former inmates that allow access to their location) or changing the city for which the establishments' data are presented (in the case of former inmates that do not allow access to their location).

Out of the six tasks proposed in the usability tests that preceded the last feedback interview, mentioned in Section 4.1.2, users were able to perform the first five with ease, which was rated by the team as easy or intermediate tasks (being three easy tasks and two intermediate ones). Regarding the last task, rated by the team as hard, one of the former inmates managed to accomplish it with some difficulty, and the others did not manage it. Sharing thoughts out loud allowed us to precisely understand when users were getting lost in performing a task, enabling us to refine the feature to be tested again in the future and perhaps validated in further usability tests.

From the feedback interviews with the former inmates mentioned at the end of Section 4.1.2, we were able to uncover important functionalities that had not been previously suggested for the application, and possibly will be incorporated into future

versions. Features such as providing information about some organizations whose purpose is to also assist former inmates in the reintegration process into society, as a tangible alternative to the application's services, or providing free cultural and sports programs for the app's public, have been suggested by the interviewees.

When asked whether they believed their suggestions to the application had been met so far, we received positive responses. Also, upon being asked if they considered their contributions to our team to be essential to the app's development, they all answered that we probably would not have achieved the same level of product quality without their direct contribution, alongside the stakeholders. The following are some passages from the former inmates' feedback:

Former Inmate 1: "It is easier for you people to improve the app development by testing it with the users that will access it. (...) I always think that when we create a product, we need to test it or create it according to the needs of the target audience that will be using it and that already know the reality regarding the context of the app."

Former Inmate 2: "In any solution that is developed for the community, for society, it is essential that it is minimally built together with the target audience that will use it. It is much more effective and much more assertive for you to build together with the end-users rather than having four or five people come up with a solution without really knowing if they will have a positive effect on the target audience that will use it. (...) I believe that the specialists, that is, the researchers and developers that are involved, will feel fulfilled when they create a product together with the end-user. I think it is an important addition, not only for this product but for any other one that concerns collective use. This development together with the end-user, in our case, the former inmates of the Brazilian prison system, I think is fundamental."

Therefore, we can state that the usage of Design Thinking techniques in eliciting requirements for the application development was positive, once it enabled us to achieve a satisfactory outcome capable of attending to the target public's necessities. It is also important to emphasize that this approach was beneficial not just to the University's development team and researchers, but also to the stakeholders who contributed to the project, since they could notice their contributions were essential to the development.

4.2 | Results of the Second Study

4.2.1 | Results of Former Inmates' Interviews and Usability Tests

Besides the three former inmates mentioned in Section 4.1.2, 30 former inmates were contacted to participate in semi-structured interviews to assess the application and suggest improvements and new functionalities. Among these, seven accepted to participate. Upon the first contact, via e-mail or WhatsApp (depending on how the CNJ provided researchers with their contact information), they were asked to download the ESVirtual app in advance so that the app would already be installed on their devices by the time of the interview. The version of the app used for these interviews was the same as shown in Table 4. There were the most diverse profiles among the seven former inmates interviewed, represented in Table 5 as 4 to 10.

Table 5 Former inmates' profiles participating in the second round of interviews

Former Inmate	4	5	6	7	8	9	10
Age	34	45	54	36	27	33	31
Region	Roraima	Mato Grosso	Rio de Janeiro	Roraima	Roraima	Roraima	Rio Grande do Norte
Ethnicity	White	Pardo ⁸	Pardo	Pardo	Pardo	Pardo	Pardo
Gender	Male	Male	Female	Male	Male	Male	Female
Part of the LGBTQIA+ community	No	No	No	No	No	No	No
Has a disability	Yes, but has no impact on using the app	No	No	No	No	No	No
Is a foreigner	No	No	No	No	No	No	No
Time in custody	6 years (closed regime)	1 year and 7 months (closed regime)	10 years (closed regime)	7 years (closed regime)	8 years (semi-open regime)	7 years (closed regime) and 3 years (semi-open regime)	8 years and 7 months (closed regime)

Continue on the next page

Table 5 Former inmates' profiles – continued from previous page

Former Inmate	4	5	6	7	8	9	10
Have children	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School degree	University Education	High School	High School (incomplete)	University Education (incomplete)	University Education (incomplete)	University Education (incomplete)	Primary School (incomplete)
Ease of use of mobile apps	Has a lot of ease	Has ease	Doesn't have ease	Has a lot of ease	Has a lot of ease	Has a lot of ease	Doesn't have ease
Phone's OS	Android	Android	Android	Android	Android	Android	Android

During the interviews, the former inmates were asked to perform seven tasks to assess the app's usability: 3 evaluated by the researchers as being of easy complexity, 3 of medium complexity, and 1 of difficult complexity. All tasks were contextualized with a hypothetical scenario, which culminated in the request to find the functionality that could help them solve the fictitious problem presented, as presented below:

1. You do not yet have a voter registration card and would like to have one issued. What documents will be required to obtain one? (easy complexity)
2. You want to take a course on HTML concepts and techniques for creating websites. Find a feature in the application that can offer you this content. (medium complexity)
3. You want to know how your trial is progressing. Check your legal status using the application. (easy complexity)
4. You need to get vaccinated. Find the nearest facility that can provide you with this service. (medium complexity)
5. You are interested in choosing and developing a new career path. Find in the application a feature that helps you in this process. (medium complexity)
6. You are interested in obtaining the Family Grant (Bolsa Família) and are wondering if you are entitled to this benefit. Find information about Bolsa Família in the application. (easy complexity)
7. You will be traveling to the city of Goiânia, in the state of Goiás, and would like to know your community restaurant options to plan accordingly. Find community restaurants in the city of Goiânia. (difficult complexity)

As with the previous interviews, these were also conducted via video conference monitored by the researchers, who also asked the interviewees to share their screens and verbalize their thoughts out loud in the previously mentioned "think aloud" process.

Of the seven respondents, five agreed to share their screens. The other two refused, either because they had not downloaded the app yet, or because they were suspicious of the app's security at first. In these cases, they were asked to guide one of the researchers in using the app in real-time, specifying actions such as when to scroll the screen, which buttons/links to press, and any other relevant interactions. In these cases, we also asked them to verbalize their thoughts aloud.

All the former inmates interviewed successfully completed the three tasks of easy complexity and 2 of the tasks of medium complexity. For one of the tasks of medium complexity, four former inmates could not complete it due to a lack of clarity in the functionality title. This title was changed, as suggested by the interviewees. Thus, the change has already been included in the upcoming release of the app.

As for the high complexity task, no former inmate was able to accomplish it. This feedback was necessary so that the project team could reevaluate this functionality and implement improvements in the app's upcoming release. When asked if the app was, in general, difficult to use, the interviewees affirmed that it was not. We highlight some of their reports:

Former Inmate 4: "I, particularly, had no difficulties at all. It was very easy to download and navigate."

Former Inmate 5: "Amazingly enough, it (the app) is very functional. It's very clear, and the indications on it are wonderful. It works well!"

⁸The term Pardo is used in Brazil to refer to people of mixed ethnic ancestries: Pardo Brazilians represent a diverse range of ethnic backgrounds⁵⁹.

Former Inmate 6: "Look, it's funny, I'll tell you something: I used to find it hard to use apps. But then, this one, when you sent it to me and I used it, I found it so easy."

Two graduates, however, made complaints about the unique access key to consult the legal situation through the Unified Execution Electronic System (SEEU). One of them said he did not know how to get it, while another said he got the key at the Fundação Nova Chance but did not keep the information because he believed it was a one-time key.

Former Inmate 5: "I got a key there at Nova Chance, you know? (...) Then I put it on and it worked, but it doesn't work anymore! It only worked that day."

The application, however, cannot provide information related to the legal situation of people who have been or are deprived of liberty without entering the access key for privacy and security reasons. For this reason, to address this issue, we have inserted in this feature the information on how to get the key: through a request in the court in which the case is being processed, through a request at the service desk. In addition, a warning was inserted stating that the key must be informed at each new access since the application does not save the users' information.

In addition to assessing the usability of the already released application, the interviewees were also asked about the features they considered most important to have in the app. The most frequently mentioned feature by former inmates was the "Legal situation" feature, which six out of seven respondents mentioned. Next in line are "Professionalizing courses", "Documents and Benefits", and "Health", which were mentioned by three respondents each. The functionality "Temporary housing" was mentioned by two former inmates, and finally, "Contact with the Social Office", and "Free legal aid" were mentioned by only one former inmate each. Although not considered irrelevant, the other features were not mentioned as the most important.

Aiming to learn about possible functionalities not yet offered by the application, the interviewees were asked to suggest services not currently available in the application if they considered them relevant. Thus, several proposals were made for new features that, according to them, could further support the inmate population and their families. The main one, as expected, was having the app provide job offers.

The reason is clear: according to Brazilian prison regulations, the person deprived of liberty, which is in the closed regime, when he or she has reached the required time to progress to the semi-open regime, can only leave the prison during the day if he or she has found a job opportunity. We highlight some reports:

Former Inmate 7: "For him (the person deprived of freedom) to be able to move on to this next stage (the semi-open regime) he has to have a job offer, okay? So, here's what I tell you: the first thing that must be within the application is the access to family members of possible jobs that may give this inmate the possibility of semi-open regime, so that he can really leave the prison system. Without this he will not leave."

Former Inmate 8: "The semi-open regime inmates, they are re-socializing, looking for a job. And they can only leave the closed regime if they find a job offer. So, the family members look for jobs for them, when they have the benefit of temporary release, they go out to look for jobs, and hardly ever do they find someone who wants to give them a job. So, the most essential thing would also be this help with employment for those who (...) want to leave to work, to support their family and change their lives."

Because of this difficulty faced by former inmates, coupled with the desire to progress to a semi-open regime, many former inmates end up taking on voluntary work, exchanging their labor for the possibility of leaving prison for a few hours a day:

Former Inmate 4: "I went to around three job interviews, and all three companies (...) practically said, "You're hired," but when I told them I was an inmate, they kicked me out. They said they would get in touch, but it's that old story, you know, they never did. Today I am working voluntarily in my church. (...) I have majored in administration, computer science, but I am a cook there today."

Furthermore, even when the person deprived of liberty manages to progress to the open or parole regime, the difficulty in getting a formal job continues:

Former Inmate 6: "When you get out, you go out with no job... Usually you leave with nothing, no clothes, nothing, right? Then it gets kind of difficult."

Thus, whether it is so that they can progress in their regime, financially support their family, and/or get conditions to lead a dignified life without the need to resort to crime again, the request for a feature that brings job offers for those who are or have already left the Brazilian prison system is unanimous among the interviewees. This feature, however, was not implemented since, as already mentioned, the team responsible for the content and development of the app was not successful in establishing a partnership capable of offering such opportunities. We hope that soon we will have a partnership and can offer this functionality in the app to former inmates.

Another frequent suggestion among the interviewees was spreading the word about possible ways to reduce their sentences. According to Article 128 of the Brazilian Criminal Enforcement Law (Law No. 7.210, of July 11, 1984)⁶⁰, "the time deducted shall be computed as a sentence served". Thus, there is a great interest among the people deprived of freedom in reducing the time spent in prison to achieve their regime progression and, consequently, their freedom as soon as possible.

Some of the possible methods mentioned as means of obtaining sentence reduction by this public were: completing elementary, high school, and university education, in appropriate cases; performing work; taking the National High School Exam (ENEM); taking professionalizing courses; and performing reviews from books read within the prison system. Among these possibilities, only professionalizing courses are offered in the application. However, they are still not highlighted for their ability to reduce sentences.

Former Inmate 4: "If you could add here the article of the Criminal Enforcement Law, which talks about remission, then it would be interesting for him (the inmate) to have this information."

In addition, it was also requested by one of the former inmates that the application should enable access to a virtual copy of personal documents, such as the judge's authorization to remain out of jail (in the case of a semi-open regime) or at home (in the case of an open regime) after the established time of the day.

Former Inmate 8: 'When the inmate is in an open regime (...) he has a curfew to go home. (...) But if (...) the judge authorizes you to (...) study, go to college, take courses, go to church... Then he will add to that time. But if you are stopped on the street by a guard, by a policeman, you will have to show a document that proves that you are backed up. So, if the application could show this document, (...) then it would help. Because then we wouldn't have to carry around a piece of paper, you know?'

Another suggestion given by the interviewees was regarding the dissemination of the application. Of the seven interviewees, only three became aware of the application through the recommendation of employees of the Physical Social Office of their regions. The others found out about the application through the researchers' team contact. Of these, one said he did not want to download the application because he did not trust the veracity of the service. In addition, one former inmate refused to participate in the interview claiming that the researcher's contact was certainly a scam.

According to the National Survey of Penitentiary Information of the National Penitentiary Department⁶¹, the number of released individuals from the prison system due to the Release Orders and Exit Permission (Art. 120, Criminal Enforcement Law) in 2021 was 217,746⁶¹. However, by November 2021, the number of downloads of the ESVirtual app in the App Store and Google Play stores did not exceed the five thousand mark. This shows that, although it has great potential for support, as stated by the interviewees themselves, the app has not yet been able to reach much of its target audience. Therefore, the interviewees emphasized the need for more effective advertising of this service, stating that all or most of their colleagues released from the prison system have not yet had access to ESVirtual due to a lack of knowledge.

Former Inmate 5: "You have to invest a little more in advertising it, see? You have to spread the word a little more on the radio or television about the application. (...) I get my cell phone, I show it to the guys (other former inmates of the prison system), and they don't believe me. I'm telling you, you must spread the word more!"

This result allows us to infer that although the application has received positive feedback from the former inmates interviewed, we still notice the shortcoming of a much-requested feature by this public: job offers. In addition, despite already having several features that aim to support the prison inmate in the resocialization process, as well as their families in the difficulties faced when trying to support the relative deprived of freedom, it is also noted that there are still several possibilities that can be added in order to increase this support further.

Former Inmate 5: "I don't know if there will be a marketing campaign within the system, or in the media, how it will be, but (...) I have already noticed that the thing (the application) is very incredible, it has a lot of information, it is very positive, and it would be a waste if people who leave the prison system didn't have access to this information here, you know?"

Former Inmate 9: "I speak here of my city, in jail... Man, a booth, a poster, something with this application information, it would be interesting, because what is seen is remembered, right? (...) At least this most important information."

The need for greater dissemination of the application by both the National Council of Justice and its partners is noteworthy since this deficit not only makes the ESVirtual application not found by a large part of its target audience, but also generates distrust in those who learn about the service from untrustworthy sources.

4.2.2 | Evaluation Questionnaire Results

Twenty-one former inmates of the Brazilian prison system answered the online questionnaire to evaluate the ESVirtual application. 10% of the participants stated that they had an incomplete primary school degree, 5% claimed to have a complete primary school degree, 25% had an incomplete high school degree, and 20% had a complete high school degree. 25% of the participants had an incomplete undergraduate degree, and 15% stated they had a university degree, a master's degree, or a doctorate, as shown in Figure 5 (a). Most of the former inmates have been using mobile apps for more than one year. 83% of the participants stated that they had not gone to a Physical Social Office in person. Among the 17% who have been to the Physical Social Office, only 43% stated that their questions were answered there.

55% of the participants used the ESVirtual app to search for something specific, and 45% used it to get to know the app's features. Ten participants stated that initiatives such as the app are essential for the resocialization process and that the app supports the resocialization process of the former inmates. Nine former inmates stated that the app is easy to install, eight stated that it is easy to use, and 6 participants stated that the app is available when he needs it. 47% of the participants reported that they were satisfied with using the app, 10% reported that they were dissatisfied, and 42% were neutral, as presented in Figure 5 (b).

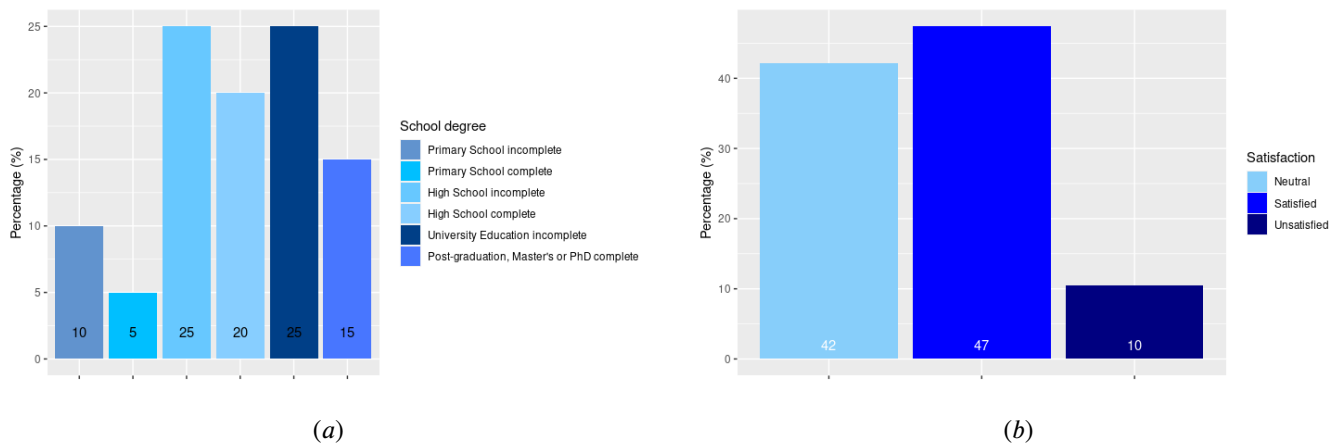


Figure 5 Figure (a) shows the school degree, while (b) shows satisfaction regarding the application's use.

According to the perception of 71% of the respondents, initiatives such as the application are important for their resocialization process. 14% did not consider this initiative important, and 14% were neutral, as presented in Figure 6 (Q13.a). 86% of the survey participants considered that the application supports former inmates' resocialization process, and only 14% stated that it does not (Figure 6 Q13.b). 67% stated that the app is easy to install, 17% were neutral, and 17% disagreed with this statement (Figure 6 Q13.c). 50% stated that they find the app easy to use, 38% stated that they do not find the app easy to use, and 12% were neutral (Figure 6 Q13.d). 44% stated that the app was available when needed, 22% were neutral, and 33% reported that the app was not available when needed (Figure 6 Q13.e).

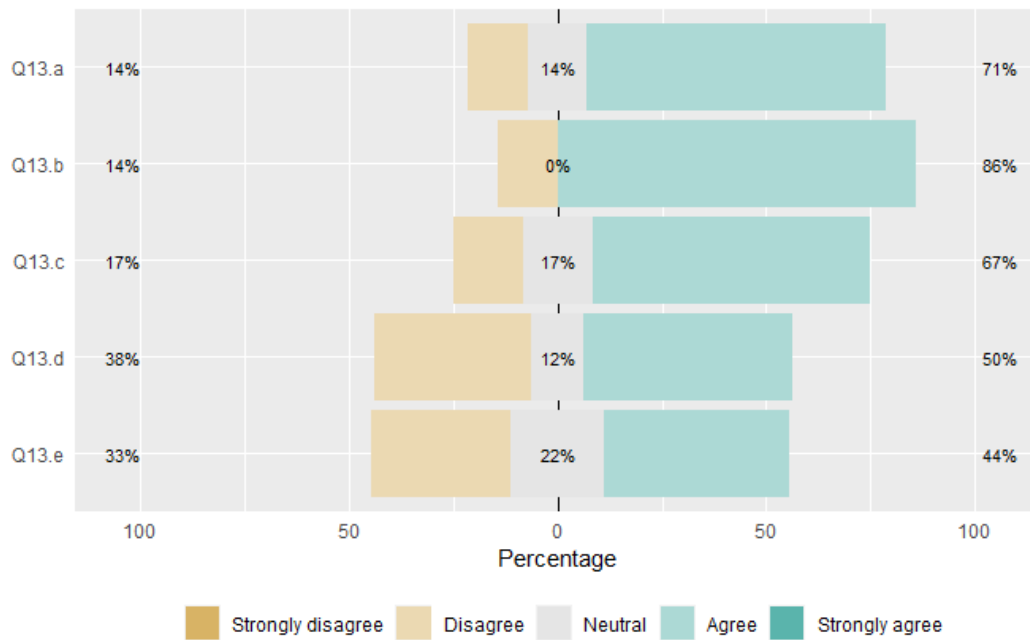


Figure 6 Respondents' perception of the application

Regarding the usefulness assessment of the functionalities offered by the application regarding the former inmates' social reintegration process, 46% considered the "Temporary Housing" and "Food establishments" useful, as presented in Figure 7 (Q15.a and Q15.b). 50% of the former inmates considered "Useful Directions and Addresses" useful (Figure 7 Q15.c), 42% of the respondents considered "Healthcare facilities" useful (Figure 7 Q15.d), 50% "Documents" (Figure 7 Q15.e), 58% "Legal Situation" (Figure 7 Q15. f), 46% "Professionalizing Courses" (Figure Q15.g), 45% "Starting over" (Figure 7 Q15.h), 50% "Guardianship of children and teenagers" (Figure 7 Q15.i), 45% "Treatment for alcohol and other drugs abuse" (Figure 7 Q15.j), 45% "Other former inmates' stories" (Figure 7 Q15.k).

64% of the former inmates considered the "Benefits, allowances and other services for the household" functionality (Figure 7 Q15.l) useful, 45% considered "Free Legal Assistance" (Figure 7 Q15.m) useful, and 36% considered the "Contact the Social Office" (Figure 7 Q15.n) useful. According to the participants' perception, the least useful functionality in ESVirtual is the "Contact the Social Office", and the one considered most useful was the "Benefits, allowances, and other services for the household".

4.2.3 | Results Interviews with Physical Social Office employees

Thirty-two Physical Social Office employees were contacted to be interviewed. They work at the office as psychologists, social workers, legal advisors, interns, technicians, and managers. Among them, twelve employees accepted to participate in the semi-structured interviews, that were conducted using a video conferencing tool. On average, they lasted 17 minutes. The purpose was to understand the employees' perception of the ESVirtual app and its usefulness. As results from the interviews, it can be highlighted that: (i) many employees still don't know de app but became motivated to get to know it and spread the word about it; (ii) the most prominent and useful features in the opinion of employees were: Documentation, Stories from other former inmates, Useful addresses, Starting over, Professional courses and Temporary shelters; (iii) the most sought after services in physical offices are: job search and information on issuing documents; (iv) some employees mentioned that some factors may delay the application's dissemination, such as: insufficient access to the Internet in places like Amapá⁹ and inmates without access to a cell phone; (v) the fact that the service offered at the offices is extended to family members is considered significant for the public served.

⁹Amapá is a state located in the northern region of Brazil.

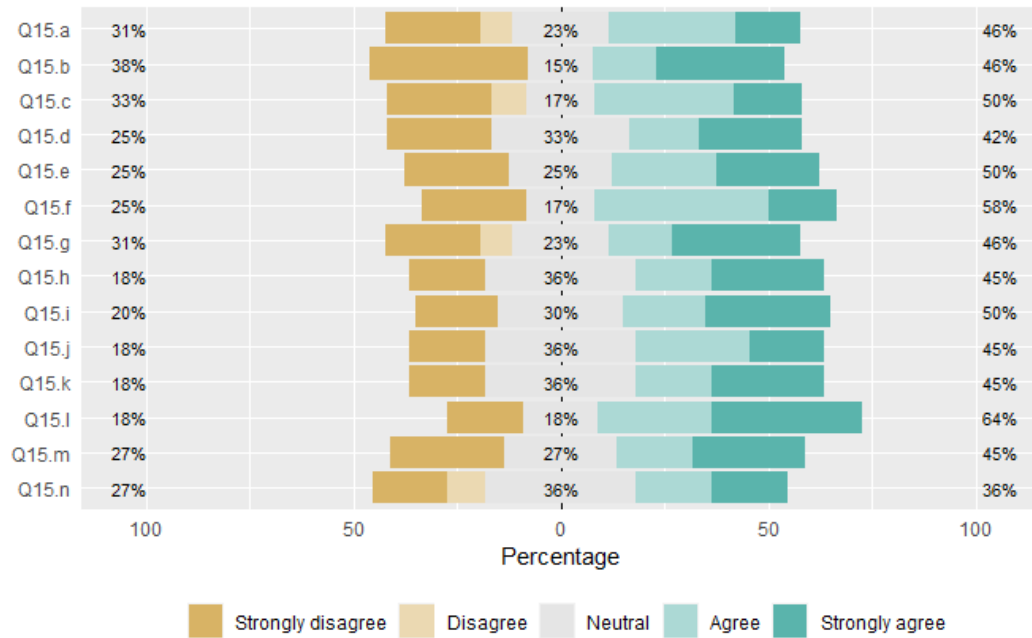


Figure 7 Respondents' perception of the functionality usefulness provided by the ESVirtual in their resocialization process

Among the interviewees that already know the app, they all affirmed that: initiatives such as the app are important for the process of integration of former inmates into society; the app is easy to be installed and used. Some relevant quotes obtained during the interviews are:

"The information about how to obtain documentation deserves to be highlighted, because many inmates that go to our offices don't have all documents. In the app, I found information that I didn't even know about a document that can be retrieved in the electoral registry to obtain a federal individual registration (one of the most important documents in Brazil)".

"The functionality called 'Starting over' is very important because it contains information about how to prepare for a work interview. Many inmates don't know how to behave in this situation because they come from another reality. Therefore, it's important to teach them".

"The part called 'Guardianship of children and teenagers' is relevant because it explains about unilateral custody, shared custody, and where to find the Public Defender's Office closer to the person".

"One of my favorite parts of the app is 'Stories from other former inmates', because it allows the inmates to develop other perspectives and help them see that it is possible to change. These examples are very useful to reduce the frequent negative speech".

4.2.4 | Outcome of the ESVirtual after Usability Tests and Interviews

After analyzing the usability tests and interviews discussed in Sections 4.1.2, 4.2.1, 4.2.3, and the questionnaire discussed in Section 4.2.2, the application underwent several changes, as follows:

- Improvements in functionalities to make user navigation more user-friendly;
- Addition of new functionalities based on feedback from former inmates and Physical Social Office employees, as well as functionalities suggested by stakeholders;

- Removal of functionalities that were included in the initial planning.

The complete list of functionalities of the app's version (as well as the reason for excluding some of them) is presented in Table 6.

Table 6 List of application functionalities after usability tests and interviews with former inmates

Functionalities kept as in the previous version	
Temporary housing	
Food establishments	
Healthcare facilities	
Professionalizing courses	
Treatment for alcohol and other drugs abuse	
Other former inmates' stories	
Useful Directions and Addresses	
Guardianship of children and teenagers	
Functionalities with improvements based on usability tests and interviews	
Documents	To make the functionality clearer for the user, we have removed benefits and allowances information and kept only the documentation information in this section.
Benefits, allowances and other services for the household	We created a new feature to contain the information about benefits and allowances that were in the old "Documents and Benefits" section. In addition, we have added other services for the family, such as the Social Assistance Reference Center (CRAS), the Specialized Social Assistance Reference Center (CREAS), and Assistance Services for Women.
Start over - Work and Career Training	We added the term "Work and Career Training" to the feature's title, since users, not being familiar with the Start Over program, were unable to identify the purpose of this section.
Settings	Because of the interviewees' difficulty in finding this feature, we tried to make it more prominent so that it would not remain unnoticed by the application's target audience.
New functionalities (added per the interviewed former inmates' or stakeholders' suggestions)	
Free Legal Assistance	It provides free legal assistance services, such as the Public Defenders Office, the Police Report Hotline, and the Consumer Protection and Defense Program (PROCON).
Contact the Social Office	It presents contact information for the region's Social Office, such as telephone and address.
Other Services	It presents services that offer individual assistance to former inmates and their families, such as the Penitentiary Patronage, the Center for Assistance to the Former Inmate and their Families (CAEFs), the Programs for Social Inclusion of Former Inmates of the Prison System (PrEsp) and the Foundation for Workers' Support (FUNAP).
RAESPs - Care Networks for Former Inmates	It presents contact information for the Care Networks for Former Inmates (RAESPs), a social movement for mobilizing, articulating, and strengthening institutions and groups that work with issues related to the prison system.
Community Councils	It presents the Community Councils, mechanisms for assistance, communication, and defense of the rights of people deprived of liberty and their families.
Gender and diversity	It presents specialized services for people of distinct genders and diversities, such as women, the LGBTQIA+ population, refugees, migrants, indigenous people, quilombolas, people with disabilities, the elderly, and services aimed at racial equality.
Culture and Recreation Services	It features free or low-cost culture and leisure services, such as theaters, museums, sports, and cultural workshops, and libraries.

Table 6 – continued from previous page

Useful Telephones Numbers	It presents several free service telephone numbers throughout Brazil. Most of them are emergency services, such as Ambulance, Women's Assistance Call Center, Fire Department, Police Report Hotline, Racism Report Hotline, and Public Health Hotline. However, in addition to the emergency services, there are also other national services that can be useful to former inmates and their families, such as the Tutelage Council, Post Office, Social Security, and others.
About the application	It presents information from the app itself, such as the purpose of the application (in text and video), partners, current version, and link to the app assessment questionnaire.
Features removed that were included in the initial planning	
Stages of Criminal Rehabilitation	This functionality has been incorporated into the "Legal Situation" section.
FAQ	To make it easier for former inmates to access the answers they need, we believe that a chatbot mechanism would bring a better result. Thus, this functionality was postponed due to the high complexity of developing a chatbot for the application.
Location Setup	This functionality has been replaced by "Settings".
Free Wi-Fi spots	This feature was not developed because of the lack of security characteristic of Internet connections over public Wi-Fi networks.

The final result of the application can also be found by downloading it directly from the Google Play ¹⁰ and App Store ¹¹.

5 | LIMITATIONS AND THREATS TO VALIDITY

As with any other research, there were threats and limitations related to its conduction. In this research, there has been a frequent access limitation to multiple end-user different profiles.

Although some attempts have been made, our team has not successfully contacted former inmates with no literacy or complete lack of familiarity with mobile devices for the interview stage. Among the cases in which we tried recruiting, most of the former inmates were unwilling to meet with researchers and stakeholders. Nevertheless, the reports of the interviewed have brought extremely valuable information.

In addition, because the period scheduled for starting tests with the prototype has coincided with the beginning of quarantine due to Covid-19, we were unable to test the application with end-users when the first version was conceived. In Design Thinking, the ideal procedure is to perform tests with these users while still in the prototyping process, to avoid rework by the development team and therefore save financial resources⁶². However, in the ESVirtual development, these tests were only possible after the completion of the first version, with a small number of users, which does not provide the optimal scenario. Regardless of this, we continued to analyze the prototypes both internally and together with the project's stakeholder team.

Another concern of the team is related to the Service Blueprint technique's first phase: the users' knowledge and access to the application. We are aware that not everyone has mobile devices with Internet access in Brazil, and we consider this a significant threat to achieving the ESVirtual goal, which is to assist in the reintegration process of former inmates into society, regardless of their financial conditions. Furthermore, we are still not informed about the application's marketing plans on the part of the project's stakeholders, so we cannot state with absolute certainty that the application's dissemination will be effective and will affect most of the target audience that could benefit from the functionalities available in the application.

All research involving human subjects has some risk, even if minimal. This research can be characterized as minimal risk. The possible risks were embarrassment when answering a question during the interview or when performing a task during the tests, or violating the participant's data confidentiality. To minimize any embarrassment, the participants were repeatedly informed that they were not being evaluated, instead the application was, and that they could refuse to answer any question and withdraw from participation at any time. As for the risk of confidentiality violation, no name, address, telephone number, or any other data that could allow the identification of the interview participants were collected. The application does not collect this data

¹⁰<https://play.google.com/store/apps/details?id=br.jus.cnj.esv>

¹¹<https://apps.apple.com/br/app/escritorio-social-virtual/id1549932681>

either. The names of the participants were not used outside of the testing sessions. Participants' names have been replaced with numbers.

6 | CONCLUSIONS

This paper sought to investigate and understand the usage of Design Thinking techniques in the development of a mobile application for socially vulnerable populations, such as most former inmates of the Brazilian prison system. During the research, we could understand the significance of involving the end-user in product design at its initial stages, since the end-user possesses the awareness of its primary concerns. It is then up to the design and development team to fully comprehend and deliver those requirements so the public can easily benefit from them.

It was further possible to comprehend the relevance of knowing the end-users' limitations well, particularly when dealing with an audience with diverse social and financial limitations. Thus, it was required to address these limitations when developing the app in an attempt to mitigate any constraints the user might have concerning the application's usage. Despite strategies adopted to simplify the application's usability by users with little to no formal education, such as adding images that depict the features or the possibility to access certain information in a narrated video format, we were unable to remove the application's textual content completely. Therefore, it is of our utmost interest to conduct interviews and tests with former inmates who have a serious degree of reading difficulty, to understand if screen readers are already a viable alternative used by this audience and whether we can find methods to enhance the app's usability further.

Another adopted approach to simplify the application's usage is to provide locations with free Wi-Fi networks. Unfortunately, this service also brings a concern regarding these networks' lack of security, which might be an issue for users sharing sensitive data. Therefore, it is of our interest to conduct interviews with a larger number of former inmates experiencing difficulties in accessing the Internet in an attempt to understand both how and if they already mitigate this situation in some other way.

Through interviews with former inmates, we also perceived that the stakeholders who actively contributed to the application's development are well aware of the interviews' significance and consider it essential to the project's success. According to them, the team probably wouldn't have attained such positive results if they hadn't involved the target audience in the app's creation since its inception. Thus, we can assume that the adoption of Design Thinking techniques towards the development of a mobile application aimed at a vulnerable user population resulted, until then, in a positive outcome and fulfilled the expectations of those involved in the project.

As future studies, it will be important to measure the application's long-term impact on the target audience, and analyze whether the features made available in the app are relevant and capable of fulfilling their purposes to the end-user. In the future, it will be also important to investigate ways to provide job opportunities for former inmates, since this is one of the main necessities they have. In addition, we also intend to provide improved assistance to the users through the insertion of a chatbot, which will assist them in finding the information they need in the application. This way, even if users do not navigate through all the various features already implemented, they will be able to reach the answers to their questions more easily.

We plan to develop a booklet that promotes ESVirtual and that, when handed to the former inmate on their release, encourages them to download the application and take advantage of its features. Therefore, we can guarantee that everyone who has been through the prison system will be aware of this service, which is available for free on Google Play and App Store.

7 | ETHICAL APPROVAL

Research projects involving human subjects must obtain an ethics committee approval. Therefore, a project entitled "ESVirtual application evaluation" was submitted to the University of Brasilia (UnB) Ethics Committee, which is registered to the National System linked to the Ministry of Health¹². It obtained the identifier code in the National Authority of the National Health Council (CEP/CONEP) system 50021421.1.0000.5540. The purpose of the project was to evaluate the application by using Usability evaluations, interviews, and questionnaires with former inmates and physical Social Offices employees. The approval was obtained under the official measure number 4.888.594, on August 5th, 2021.

¹²<https://plataformabrasil.saude.gov.br/>


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9 | DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available in the repository at Zenodo


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