Design of a Mobile App that Targets Food Insecurity in Rural Areas in Illinois Using Nielsen's Ten Usability Heuristics.

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Human factors and ergonomics can be used to reduce food insecurity in rural areas of Illinois by using human-centered design and Nielsen's ten usability heuristics to design a mobile app that maps and manages food community services. We interviewed potential users and used an iterative process that ended up with a mockup of the mobile app that satisfies all of Nielsen's usability heuristics. Further studies could be made to evaluate the overall usability of the app before developing it.

INTRODUCTION

According to the United States Department of Agriculture (USDA), food insecurity is a household-level economic and social condition of limited or uncertain access to adequate food (USDA Economic Research Service, 2021). 10.5 percent of the United States (U.S.) households were food insecure at least one time during 2020, meaning that 13.8 million of households in the U.S. had difficulty providing food for all family members due to lack of economic resources (Coleman-Jensen A. , Rabbitt, Gregory, & Singh, 2021). This includes either low food insecure or very low food insecure.

Food insecurity is associated with multiple health problems. This means higher healthcare costs and higher risk of mortality due to the muscles mass loss and frailty at earlier ages among other factors (Soederberg Miller, Tancredi, Kaiser, & Tseng, 2020). There are other diseases caused by food insecurity. For example, among children, food insecurity is associated with anemia or birth defects as well as aggression, anxiety, and cognitive problems (Gundersen & Ziliak, 2015).

However, food insecurity is unevenly distributed among the population. On an overview, most of the food insecure households are low income with at least one child as a family member (Coleman-Jensen A. , Rabbitt, Gregory, & Signh, 2021). Furthermore, there are some minorities that are more severely affected than others. Some examples of population groups more prone to suffer food insecurity are single female with children or people living in rural areas (Coleman-Jensen A. , Rabbitt, Gregory, & Signh, 2021; Dean & Sharkey, 2011).

Rural areas have less access to food, as they are more food insecure, and have less food community services than non-rural areas (Dean & Sharkey, 2011). This means that people living in rural areas have more risk of suffering from food insecurity, but they also have less access to resources that could help them to get an adequate amount of food.

Only half of the food insecure population benefits from one of the three largest Federal nutrition assistance programs, meaning that the lack of knowledge and resources to access these programs impedes food insecure people to benefit from all the resources that could reduce food insecurity in their household (Coleman-Jensen A. , Rabbitt, Gregory, & Signh, 2021). It is important that people can access this information to prevent all the health problems associated with not having a healthy adequate diet. This, together with the fact that households in rural areas are more vulnerable to food insecurity, handicaps this minority among other groups.

Human-centered design is a Human Factors and Ergonomics (HFE) approach in which the final user is involved in a direct way during the design, development, and testing processes of a product (Harte, et al., 2017). This approach can be used to target food insecurity in rural areas in multiple ways. Even though most of the food insecure population has low income, more than three quarters of them own a smartphone (Vogels, 2021). Therefore, a mobile app could be designed using the methods stated by human-centered design to assure that food insecure people in rural areas have access to the resources they can benefit from.

To make sure that food insecurity is reduced among U.S. rural areas by using this app, we should ensure some usability standards. Jakob Nielsen listed ten usability heuristics that an interface should follow to reduce confusion among the users and reduce misuse. Nielsen's ten usability heuristics are:

1. Visibility of system status
2. Match between system and the real world
3. User control and freedom
4. Consistency and standards
5. Error prevention
6. Recognition rather than recall
7. Flexibility and efficiency of use
8. Aesthetic and minimalist design
9. Help users recognize, diagnose, and recover from errors
10. Help and documentation

(Zhang, Johnson, Patel, Paige, & Kubose, 2003).

By using a proactive approach and involving the final users in the whole process of development of the system and using Nielsen's ten usability heuristics, this paper is going to focus on the development of a mobile app. Therefore, the objective of this paper is to create the first mock-up of an app that aims food insecure people in three rural areas in Illinois

(Streator, Pontiac, and Sheffield) using human-centered design and Nielsen's ten usability heuristics.

METHODS

Requirements Elicitation

This paper is part of a bigger project that aims reducing food insecurity in rural areas in the state of Illinois. Before starting the design of the app, we had to conduct interviews with users currently suffering or who had suffered from food insecurity. The Human Factors in Sociotechnical Systems (HFSS) laboratory team at University of Illinois Urbana-Champaign (UIUC) designed an interview that included general questions about the user's experience with food insecurity. Two participants were interviewed in total for about an hour each.

The aim of the interview was to try and come up with ideas to improve the experience of people with food resources, as well as getting to know the scope of the problem the project assesses. Therefore, I selected the relevant information that was useful for the development of the mobile app.

Data Collection

The second step was to collect information about the food community services that Streator, Pontiac and Sheffield currently has to target food insecure household. To do this, I relied on the interviews to know the different services the users had been using. Further research was done using Google. All the different options were studied. The data collection aimed the following information about each one of the food community services in Streator, Pontiac, and Sheffield:

- What do they offer?
- How do they offer the service?
- Are there any requirements the user has to fulfill to be eligible to benefit from that service? If so, what are they?
- Application procedures.

Software

The HFSS laboratory team used Zoom to interview both participants. I did all three iterations using LucidChart (www.lucidchart.com). I used the wireframe template for the first two iterations and the UI/UX prototype template for the third iteration.

Design

For the design of the app, I used an iterative approach. I increased the fidelity of the design with each iteration until I ended up with a high-fidelity mockup of what the app would look like in real life.

First iteration

For the first iteration, I used two main ideas or concepts:

1. The first one was the information I took out from the interviews. This included key requirements that should be in the mobile app to make sure it aims the food insecurity problem. It included information about what resources users used, what relationship did they had with each resource, what would they change from each service, ideas that would make the services more accessible, other services they did not use and why did they not use them, etc. All this information built up the main structure of the app that was captured in the first iteration.
2. The second idea was the flexibility and efficiency of use usability heuristic, which means speeding up the interaction for the expert user such that the app can cater both inexperienced and experienced users (Zhang, Johnson, Patel, Paige, & Kubose, 2003). I kept all the essential information in the main screens or one click away from the main screens. By essential information I mean all the information that a user indispensably requires to use the main functions of the app. In this way, unexperienced users can find important information easily. The rest of extra screen should be used by more experienced users. These screens include further functions that the app has that are non-essential but that increases the efficiency of the system, such as shortcuts.

All these concepts were portrayed in a wireframe diagram using boxes with simple language and arrows that showed connections between screens.

Second iteration

For the second iteration I added new usability heuristics as well as reinforcing the concepts I used in the first iteration. In total, I included four of Nielsen's usability heuristic to the second iteration, which had a higher fidelity than the first iteration, but was still a wireframe diagram. This means that each box corresponds with a screen and the information inside each box includes all the information that screen will show in the third iteration. The arrows still showed connections between screens. The heuristics I considered in this iteration where:

1. Match between the system and the real world, which means that the app should follow real-world conventions (Zhang, Johnson, Patel, Paige, & Kubose, 2003). Therefore, I made sure that the screens came in logical order. This means that the screens should come in the same way the information comes to the user if she/he was doing the task in real life and not through an app.
2. Consistency and standards, which means that the app should follow platforms conventions (Zhang, Johnson, Patel, Paige, & Kubose, 2003). To include this heuristic, I linked the essential tasks to similar mobile apps world widely used to make the new app consistent with the most used apps in the world among older and younger people. I also made icons of commonly used actions such as delete or edit also follow platform conventions.

3. Recognition rather than recall, which aims minimizing the user's memory load by making options visible (Zhang, Johnson, Patel, Paige, & Kubose, 2003). To include this heuristic, I made sure that all the information to perform tasks was on the menu tab without submenus. I also made the information to access less intuitive tasks could be accessed from several places (at least two, occasionally form three different places).
4. Aesthetic and minimalist design, which means that screens should not contain information which is rarely needed. To include this heuristic in the second iteration I decided to question every bit of information shown in the screens and fictionally ask the interviewed participants if that information was going to be commonly used or rarely used. I eliminated useless information and moved rarely used information away from the main screens.

As well as including all these new considerations to the second iteration, I made sure that the concepts used in the first iteration were reinforced by adding these new requirements.

Third iteration

The third iteration was the last one. In this iteration, I used a template used for prototyping mobile apps. Therefore, this final design looked how the app will really look if it was fully developed and in use. The arrows had the same meaning as it had in the first two iterations. The last concepts I included in the final iteration are:

1. Visibility of system status, so that the user is always informed about what the app is doing (Zhang, Johnson, Patel, Paige, & Kubose, 2003). To introduce this heuristic to the design of the app, I included feedback when the user performs a task. Considering especially those actions that involve changes in how the app is going to work form that point onwards.
2. User control and freedom to support undo and redo. To do this, I checked every single screen and asked myself what would happen if I wanted to change something. The app should give the user a high level of freedom to include information and perform tasks without having the feeling that the app controls what the user must do.
3. Error prevention (Zhang, Johnson, Patel, Paige, & Kubose, 2003). I decided to eliminate all error-prone conditions. I considered especially those times in which the user had to include information.
4. Help users recognize, diagnose, and recover from errors (Zhang, Johnson, Patel, Paige, & Kubose, 2003). In case of error, the user should be informed about why that error happened and what to do to prevent that error before they can even submit the change to reduce anxiety.
5. Help and documentation (Zhang, Johnson, Patel, Paige, & Kubose, 2003). To include this heuristic, I made sure that the user could access help from every single screen. I also looked for confusing terms, words, or phrases to make sure that the user could access documentation to clarify meanings.

In addition to adding all these heuristics, I made sure that none of them hinder the heuristics and ideas used in previous iterations.

RESULTS

Data

After collecting all the data, I came up with three main food community services:

1. Food banks and food pantries.
2. Supplemental Nutrition Assistance Program (SNAP) and Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), which are the two most used federal nutrition programs (Barnes & Riel, 2022).
3. Delivered options and programs, both local and federal.

First Iteration

Interviews

Form the interviews the HFSS laboratory team did, I decided to create four main screens that can be accessed by clicking to the four different icons in the lower horizontal part of the screen:

1. The aim of the first main screen (referred to as Food Pantry main screen from now on) is to map food pantries and food banks. Both interviewed participants used this food community service to get their food. They had heard from the food pantries they normally went to from other people as there is currently no official service that maps all the food pantries or food banks.
2. The second main screen (referred to as SNAP & WIC main screen from now on) is aimed to monitor SNAP and WIC. One of the interviewed participants specifically mentioned that she/he would use an app like that to check updates and changes of SNAP and WIC.
3. The third main screen (referred to as Delivered Options main screen from now on) includes the delivered options, both federal programs and local services. I decided to include this information in the third main screen because none of the interviewed used these services. However, they both stated they had problems to get to the food pantries as they rarely had gas in the car because they could not afford it. They did not know much about these types of programs they could benefit from. That is the reason I decided to include a full main screen for them.
4. The fourth main screen (referred to as My Profile main screen from now on) is a "My profile" type of

screen which is widely used in the most used mobile apps such as Facebook, Google Maps, or Instagram.

Flexibility and efficiency of use

The most important information from each screen can be accessed from the main screen or just one screen away from the main screen. For example, the food pantries open hours, which was as issue for both interviewed, are just one click away from the main screen. SNAP and WIC information, such as the money left, the last transactions and the recharge date are visible from the second main screen. In the My Profile main screen, the user can read and edit personal information, their availability schedule, etc. In the Food Pantry screen, the user can check from the main screen its exact location and can also find pins that indicates where the food pantries or food banks are located.

Second Iteration

Match between the system and the real world

An example of this heuristic applied to the app is for example the process to follow when searching a food bank. It follows the same steps you follow when looking for a location in a physical map: first find where you are, find possible locations, choosing a location, creating, and following the route to go to that specific location.

Also, the SNAP & WIC main screen matches with the order in which you would access information if you had the money in your wallet and decided to spend it. The first thing you can see is the amount of money you have left. Then, you can check your bills to see how much money you have spent and where.

Consistency and standards

The whole app is designed to be like social media mobile apps. For example, the main screens are shown and can be accessed from the lower part of the screen, the profile screen button is in the low right-hand side, the menu button is in the top right corner, etc.

Also, the Food Pantry main screen is consistent with Google Maps, which is the most used mapping mobile app (Mostafi & Elgazzar, 2021). In the same way, SNAP & WIC main screen is designed to be like most of the bank mobile apps.

The icons used as button to edit, delete, or close a screen are consistent with what Facebook, Instagram or Google Maps uses on their mobile applications.

Recognition rather than recall

The essential information can be accessed from each main screen. If the information is not visible there, there is only one way to go: to the menu button in the top right corner. Here, the user can see the list of all the information that is not shown in the main screen. The order of the buttons in the menu tab follows a logical order (starting with information about the program and ending with the "Help" button).

Also, the information considered as tricky to find can be accessed from different places. For example, it is logical to look for saved food pantries in the Food Pantry screen, but it is also logic to look for it in My Profile main screen. To make sure the user finds this type of information easily, it can be accessed from both screens.

In addition, important information can also be accessed from multiple places. For example, the information about a particular food pantry, like open hours, can be accessed from the food pantry main screen by clicking into a pin, by searching manually, by clicking into most recently visited food pantries in the menu tab or by clicking in the saved food pantries in the food pantry main screen of the My Profile main screen.

Aesthetic and minimalist design

Essential information, such as money left from the SNAP & WIC programs can be seen in the main screen. Other buttons considered non-essential because they are either aimed at users with more experience or because the same information can be accessed from easier way, are more hidden.

An example could be the option of entering the available schedule to use the filter option "compatible with schedule". Even though this option is very useful, it is not considered essential because the users can check open hours and compare them with their schedule in much easier way (one click away from the Food Pantry main screen).

Third Iteration

Similar to the second iteration, this third iteration reinforces wherever possible the heuristics and ideas included in the first and second iteration.

Visibility of system status

I made sure that the users receive appropriate feedback, especially when they change a feature of the app in a permanent way.

Some examples of this could be, when the users use the filters, they get direct feedback of how many results are going to be shown before accepting applying the filter. They also get feedback when they edit personal information or their schedule. The feedback in these cases is specific, such as "The address, middle name and income has been edited". When the user saves a location as favorite, he/she also gets specific feedback including an explanation on what does that action means ("Streatorland" has been saved into My Favorite Locations. You will receive notifications about updates of this location in your messages). The favorite locations are saved with a star shaped icon in yellow, which is consistent with other platforms conventions.

User control and freedom

To make sure this usability heuristic was satisfied, I included an exit button in most of the screens. There is also a "Back" button in the top left-hand corner visible and that can be used in every single screen. I also included the menu button in the top right-hand corner to be accessible from every screen to increase the user's control and freedom.

Error prevention

Related with error prevention, I used tools that most mobile apps use. For example, when the user tries to search for a location, he/she gets life updates of what location the user could be referring to. For example, if the user is searching for "Streatorland", he/she can get that option shown if he/she misspells the location or before he/she writes the whole name and clicks search.

I also decided to disable buttons, such as the update button that cannot be clicked if the user has not entered any information.

Help users recognize, diagnose, and recover from errors

To assess this usability heuristic, every error message includes the cause, a possible solution, and a recommendation to prevent future errors.

Even though this usability heuristic is considered important, I tried to design the app to prevent the errors.

Help and documentation

I decided to include different types of help options. The help button is visible in all the menu tabs and is positioned last in the list of buttons of this screen. The options of help are forum with other user's tips or recommendations, a "chat with us" option where the user gets life responses, a guided tutorial on how the app works and a frequently asked questions section.

Furthermore, I also included an icon next to phrasing or language that could be confusing or new for the user to access more detailed information. For example, in the filters section for the food pantry screen the user can enter the "type of pick-up". This term might be confusing. Therefore, I included an icon the user can click and get an explanation of what this term means, as well as help on choosing a type of pick-up option.

DICUSSION AND CONCLUSIONS

As a conclusion, I would say that it is almost impossible to satisfy all the usability heuristics completely. Sometimes, if you decide to use a certain heuristic, like for example flexibility and efficiency of use, you have to give up another heuristic such, for example aesthetic and minimalist design. Therefore, the overall approach is to minimize the usability heuristic violations and the severity. The final mock-up will have heuristic violations for sure.

Limitations

The main limitation I had while doing this paper was that I could not hold interviews myself with potential users to assess specific issues related with the development of the app. Even though I had access to the interviews the HFSS laboratory team held, they had a more generic view about the food insecurity problem. Therefore, I could not interview myself or design the interview questions to aim the objective of the paper due to the difficulty of finding participants that had suffered from food insecurity in one of the three locations this paper is target at (Streator, Pontiac and Sheffield).

I would have also liked to share each one of the iterations with some potential users and ask them about what they think about it, what they find useless and what they rather include. However, due to time constraints and the difficulty of finding potential users, this could not be possible.

Next steps

The next step should be to carry out a usability evaluation with the mockup before developing the app. Further studies could be held to identify usability violations. To do this, we should give the mockup to potential users and observe how they interact with the system, identifying the problems they encounter and relating each problem to a usability heuristic. Furthermore, we should recommend changes and implement them in a new mockup. This process could be iterative too, where the mockup will converge into a final design that minimizes usability heuristic violations, confusion among the users and misuse; and maximizes the overall usability of the mobile app. The design will not end up having zero usability violations, but the usability violations remaining should not be severe.

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