7-2023

Evaluating an mHealth Application for Cancer Survivors with Disabilities through Usability Testing

Kevin Baez

EVALUATING AN MHEALTH APPLICATION FOR CANCER SURVIVORS WITH DISABILITIES THROUGH USABILITY TESTING

A Thesis Project Presented to
The Faculty of the University Honors Program
Northeastern Illinois University

In Partial Fulfillment of the Requirements
of the NEIU Honors Program
For Graduation with Honors

Kevin Baez
July 2023

HONORS SENIOR PROJECT
ACCEPTANCE AND APPROVAL FORM

Kevin Baez

Student Name

EVALUATING AN MHEALTH APPLICATION FOR CANCER SURVIVORS WITH DISABILITIES

Title of Senior Project

This senior project has been reviewed by the faculty of the NEIU Honors Program and is found to be in good order in content, style, and mechanical accuracy. It is accepted in partial fulfillment of the requirements of the NEIU Honors Program and graduation with honors.

Rachel Adler — 7/31/2023

Faculty Advisor — Date

07/31/2023

Faculty Reader — Date

08/04/2023

Honors Curriculum & Standards Board — Date

Jon Hageman — 08/04/2023

Coordinator, University Honors Program — Date

ABSTRACT

The effect of cancer treatment can cause difficulties in a cancer survivor's life due to the risk of attaining a long-term disability which has potential negative cognitive, psychological, physical, and social consequences. Furthermore, post-treatment support has been shown to be severely limited, leaving many to deal with new obstacles and struggles on their own. With no real support system in place, cancer survivors with disabilities can be lost during post-cancer transition. However, mHealth interventions have been proven to effectively aid users in dealing with various health issues. We aim to support and empower cancer survivors through an application called, WeCanManage. WeCanManage supports cancer survivors while navigating everyday life by providing resources such as a platform to interact with other users and modules on ways to deal with the after-effects of cancer treatment. Using Marvel, an online collaborative design platform for creating prototypes, we designed a high-fidelity prototype of WeCanManage. We evaluated it using Nielson's 10 principles of heuristic evaluation with 22 Human-Computer Interaction university students. We modified the prototype based on the collected feedback. With the polished prototype, we conducted usability testing on 10 cancer survivors. Cancer survivors were given the opportunity to test the prototype and provide feedback to further improve the prototype's usability, effectiveness, and accessibility for a better user experience. We captured data regarding task completion, satisfaction, and survey data which included their likes and dislikes of the app as well as the System Usability Scale (SUS). Overall, usability testing showed

positive results for the design of our prototype with only a few design issues found and addressed through modifications.

ACKNOWLEDGEMENTS

I would like to express my gratitude to Dr. Rachel Adler, my faculty advisor and a professor at NEIU, for the resources and support provided to me through these last two years. Your guidance was pivotal in the completion of this thesis and my understanding of the research process. I will always appreciate your essential feedback and help during this time. I would also like to extend my appreciation to Dr. Jon Hageman for the advice and help during my time in the University's Honors program. The funding, presentation, and research opportunities have led the Honors program to be the most influential program to my professional and academic development while at NEIU. Lastly, thank you Dr. Aisha Shah and Dr. Deepa Pillai for being the second and third reader of my thesis, which has led to significant improvements.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

As of January 2019, there were an estimated 16.9 million cancer survivors in the U.S, which is projected to increase to 22.2 million by 2030 (National Cancer Institute, n.d.). In total, 40% of cancer survivors experience long-term physical, cognitive, and psychological effects of cancer and its treatments (National Research Council, 2005). These disabilities can impact all aspects of a cancer survivor's life such as their overall health, quality of life, ability to work, and social participation. The transition from active treatment to long-term survivorship of cancer can be difficult due to the limited resources provided for cancer survivors with newly acquired disabilities. Less than 10% of people with cancer-related impairments receive services (Pergolotti et al., 2015). A cancer survivor's needs usually go unaddressed and with limited guidance, they have to overcome challenges alone. As such, it's important to provide further resources that are well-tailored to their needs and evaluate them with different methods to ensure the they are accessible and useful to cancer survivors.

Mobile health (mHealth) applications provide users with medical care and practices through a mobile device. Medical care in mHealth applications can come in different forms such as monitoring an illness, tracking the progress of recovery, experiencing an intervention by professionals, and/or receiving educational resources. With 325,000 mHealth applications in 2017 alone, they cover a plethora of illnesses (Pohl, 2017). Such applications are beneficial as they bridge the gap between patients and

their medical care by providing health resources that some may not be able to access otherwise.

We designed a prototype of WeCanManage, a self-management application for cancer survivors with disabilities, to guide cancer survivors through their transition after treatment. The app will empower cancer survivors who are facing daily challenges due to newly acquired disabilities by providing guidance and resources that will teach them how to self-manage the long-term impact their treatment has on their health. Users will be provided with tools to manage cancer as a chronic condition and intervention content based on extensive literature reviews and interviews with actual cancer survivors with disabilities. The main content is provided in 4 broad modules, WeCanRelate (fosters a sense of validating and normalizing the survivorship experience, WeCanAdapt (teaches goal direction self-management strategies), WeCanBe (emphasizes mindfulness-based practices), and WeCanSpeakUp (addresses self-advocacy and disability rights). Furthermore, WeCanManage contains three additional sections to further support users, such as Connect to Peers (provide one-on-one connections with users), Community Forums (to discuss shared experiences with an entire community), and the Library (contains additional evidence-based education content). All content and features provided are made to address different concerns and challenges a cancer survivor with disabilities may face in everyday life. Therefore, it is crucial that our application is accessible to our audience and attends to their needs. We assessed this can through a series of methods for collecting data on the prototype's usability.

One way to evaluate the usability of a design and find any deficiencies is through heuristic evaluation, which can help minimize usability issues before bringing it to users.

Heuristic evaluation involves human-computer interaction experts examining an application with 10 established principles of design to find usability violations. Each principle can be rated with a severity rating from 0 through 5 to measure the severity of the design flaw that falls under that category. This gives the design team a checklist they can systematically go through which provides a fast and practical way to identify problems within the design before showing the application to users. This type of evaluation is usually done early in the development of an application to provide better insight into the design.

The process of usability testing involves collecting qualitative and quantitative data from participants that represent the target audience through a series of methods including interviews, task completion tests, and questionnaires. This data can be used to assess the design of an mHealth application and ensure it is tailored toward its targeted audience. Issues with the design can be found and changed to improve user satisfaction so that the functions, features, and overall purpose of the application can align with the wants and needs of the users.

In this thesis, we will first discuss the existing literature on evaluating mHealth applications. Next, we will discuss the design and features of the WeCanManage prototype and its evaluation through heuristic evaluation with students in a Human-Computer Interaction course as well as usability testing with cancer survivors with disabilities. We will measure the overall user satisfaction and usability of the app for cancer survivors with disabilities. The results of this work will be used to determine how the prototype can better meet the needs of cancer survivors.

LITERATURE REVIEW

The number of mHealth applications has increased throughout the years, with around 325,000 applications available in 2017 alone (Pohl, 2017). As such it is important to examine the impact these applications have on their target audience to ensure their usability, accessibility, and an overall positive experience for the users. Usability testing has been proven to be an effective method of gathering qualitative and quantitative data to determine how satisfied users would be with the product at hand (Usability.gov, 2022). There are multiple ways of conducting usability testing, but having participants that represent the average user of the product is a requirement (Usability.gov, 2022). According to one scoping review, out of 133 different mHealth applications, 105 used questionnaires, 57 used task completion, 45 used 'Think Aloud', 37 conducted interviews, 18 performed heuristic evaluation, and 13 made focused groups (Maramba et al., 2019). The System Usability Scale (SUS) was the most frequently used questionnaire with a total of 44 studies. A combination of methods was used in 88 of the studies (Maramba et al., 2019). Further, cancer was tied as the second most frequent health condition being evaluated (n=10), with only mental health being greater (n=12). Using such methods for testing can be effective in letting the design team identify issues with the product before coding, which brings a mirage of benefits in terms of development.

Additionally, usability testing results can lead to significant improvement in the application design and development process. A study conducted by Martinez, Threatt, and Rosenbloom (2018) tested the usability of a diabetes dashboard embedded in a web portal and showed the effectiveness of iterative design when combined with usability

testing. Multiple questionnaires, task-based methods, and interviews were conducted to test the usability of their design. After each round of testing, the design of the dashboard was revised in response to their findings for the next round. This resulted in usability improvements in each design iteration, improvement in comprehension of diabetes health data, and a significant jump in user satisfaction from the initial to the final product. Overall, usability testing is effective in finding design flaws that might have been otherwise overlooked and aids in giving end-users a more positive experience as it tailors the application towards the intended audience.

Involving the target audience can ensure the design of an application is centered around them. During the design of an application to monitor the social functioning of youth who are at high risk for psychosis, the design team allowed participants to test the application for one week (Santesteban-Echarri et al., 2019). After the week, they provide qualitative and quantitative data on the usability of the application through the Mobile Application Rating Scale (MARs). MARs has questions covering engagement, functionality, aesthetics, information, subject quality, and perceived feedback. These questions were implemented through an interview which prompted the collection of data and feedback from the participants. The data showed that participants cared about minimal steps to access content, customization within the app, the safety of data, more neutral images, and pushed notifications. Through usability testing, the design team was able to incorporate user feedback into their application which would benefit users and improve the overall experience within the app. This helps improve engagement and support when dealing with possible psychosis. Furthermore, questionnaires such as the

SUS and MARs can be an important tool with usability testing as they can collect both qualitative and quantitative data from participants

Reynoldson et al. (2014) tested the usability of multiple self-management pain applications. With a total of 41 participants and 12 applications, methods such as task completion, SUS, and design questionnaires were used to test all 12 apps. All the apps were either in diary or scale format to measure pain, with diaries rated higher in usability. Other feedback was collected and many issues were found with the apps' interface and text size/font. The SUS score ranged from 57 to 100, which means that apps on the lower end need to improve.

An mHealth application to support heart failure patients was created using a co-design approach where participants representing their targeted audience were part of the design process providing constraint feedback and suggestion (Woods et al., 2017). After which, usability testing was done with 12 participants. Participants were given the application for 14 days to use in a home setting. Afterward, they report their experience with the application through qualitative interviews. The Mobile Application Rating Scale (MARs) was used to score the usability of the application. Through usability testing, the design team was able to better tailor the application for end-users.

In addition to web or mobile applications, prototypes can also be evaluated through usability testing. For example, a stress management app intervention for cancer survivors improved the development of their prototype through usability testing (Børøsund et al., 2018). The start page, menu page, and first intervention module were tested on the first iteration. After feedback from the initial testing, the prototype went through adjustment, which was tested again by three other cancer survivors. Testing was

conducted through the filming of movement, follow-up questions, note-taking, and summarizing reports. The data collected was used to evaluate, refine, iteratively adjust, and upgrade the prototype. Major upgrades were made such as making the application available through tablets and smartphones and offering different formats such as text, audio, video, and pictures. Through usability testing, the design team managed to receive a good amount of qualitative data which led to major changes to the application for the benefit of users.

Similarly, usability testing was conducted on a web-based prototype for intervention for women with metastatic breast cancer (Beatty et al., 2021). The think-aloud method alongside interviews was used to test usability. With 8 participants of an average age of 63, 6 psychosocial modules were completed. All participants were able to give helpful feedback and suggestions. The participants gave positive feedback on features they enjoyed and would like to see in the final product, such as more relatable information, simpler navigation, improved worksheets, and layout modifications. Usability testing was an important step in finalizing the development info of the prototype and tailoring the resources provided toward the user's needs. The design team was able to receive positive feedback on different sections of the app while also learning about what needs to be modified and further developed. Overall, the team was able to learn the importance of building flexibility and accessibility into their program for their targeted users.

A Mental Health eClinics prototype aimed to make clinical care accessible to young people suffering from mental health issues (Ospina-Pinillos et al., 2019). Usability testing was conducted through a 90-minute testing session with task completion. A total

of four tasks were to be completed including creating an account, finding the "Need Help" button, exploring the dashboard for results, and booking an appointment. Afterward, a small questionnaire was completed. There were no issues with the first two tasks, however, tasks 3 and 4 received negative feedback. Users found the navigation complicated and booking an appointment was confusing due to the placements of the buttons. These features were improved and upgraded to provide a smoother experience for users. Usability testing led to improvements to the eClinics which will boost users' overall experience.

The SUS questionnaire was also used in studies to determine the usability of a mHealth prototype to enhance emotional awareness in patients with borderline personality disorder (Derks et al., 2019). This prototype was first designed through an iterative cycle with feedback from both patients and clinical experts. Three cycles were done in total with 3-5 participants in each. After this, the SUS questionnaire was applied in each cycle. The questionnaire was combined with interviews and other smaller questionnaires in order to receive better data from participants. The prototype ended up with a score of 78.8 from participants and 59.4 from experts. This highlights the discrepancy between experts and users in what they are looking for in a mHealth application. Overall, the prototype was developed with feedback from both the target audience and clinical experts, which led to improvements.

Another example of using SUS during usability testing of a prototype is a study conducted on a web-based self-management support prototype for adults with chronic kidney disease (Donald et al., 2021). Participants went through five scenarios and engaged in the 'Think-aloud' method. They were given open-ended questions to provide

feedback, after which they completed the SUS, with a score of 90. Finally, two researchers conducted a 60-minute interview with participants to identify issues with the prototype design and paths participants used to complete specific tasks. Such methods led to notable improvements in design and usability. Researchers realized users preferred to follow their own personal journeys and enjoyed having a variety of formats such as video, text, and audio in order to address cultural and sensory needs.

Table 1 shows a summary of the methods used in the articles mentioned above. As shown, common techniques for conducting usability testing for mHealth prototypes and applications include interviews, task completion, think-aloud, SUS, MARS, and other questionnaires. Such techniques are efficient in gathering data regarding user experience and the usability of a prototype. Other than MARS, our study used the rest of the techniques mentioned to measure the usability of our WeCanManage prototype.

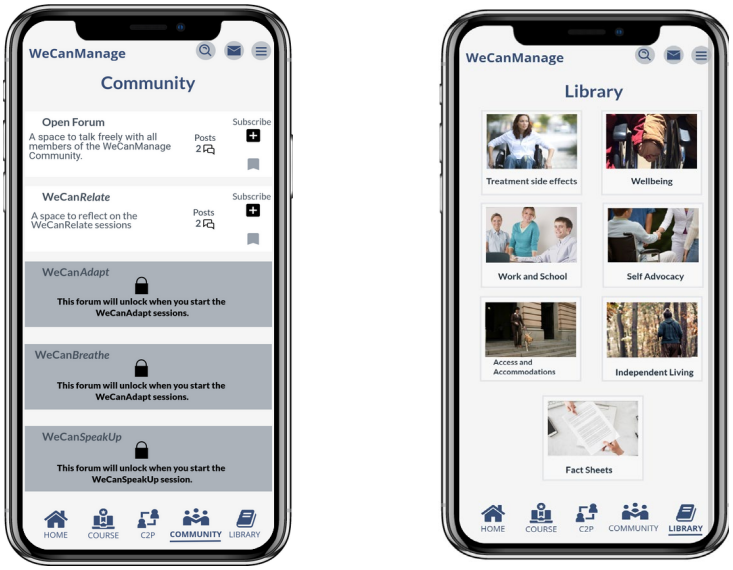
Articles	Interviews	Task completion	Think aloud	SUS	MARS	Questionnaires
Martinez, Threatt, and Rosenbloom (2018)	x	x				x
Santestban Echarri et al. (2019)	x				x	x
Reynoldson et al. (2014)		x		x		x
Wood et al. (2017)	x				x	
Børøsund et al. (2018)	x	x	x			
Beatty et al. (2021)	x		x			
Ospina-Pinillos et al. (2019)		x				x
Derks et al. (2019)	x			x		x
Donald et al. (2021)	x		x	x		x

Table 1. Common methods used for usability testing of mHealth apps.

METHODOLOGY

We designed a prototype for WeCanManage, an mHealth application designed to serve cancer survivors with disabilities who are transitioning to long-term cancer survivorship after their treatments. It was designed to empower users through problem-solving, mindfulness, and self-advocacy training with educational and collaborative content. The high-fidelity prototype was created through Marvel, an online collaborative design platform that provides tools for creating wireframes, designs, and prototypes of interactive applications. The prototype of WeCanManage allows users to view the Home, Journey (Courses), C2P (Connect to Peers), Community (Community Forum), and Library (see Figure 1).

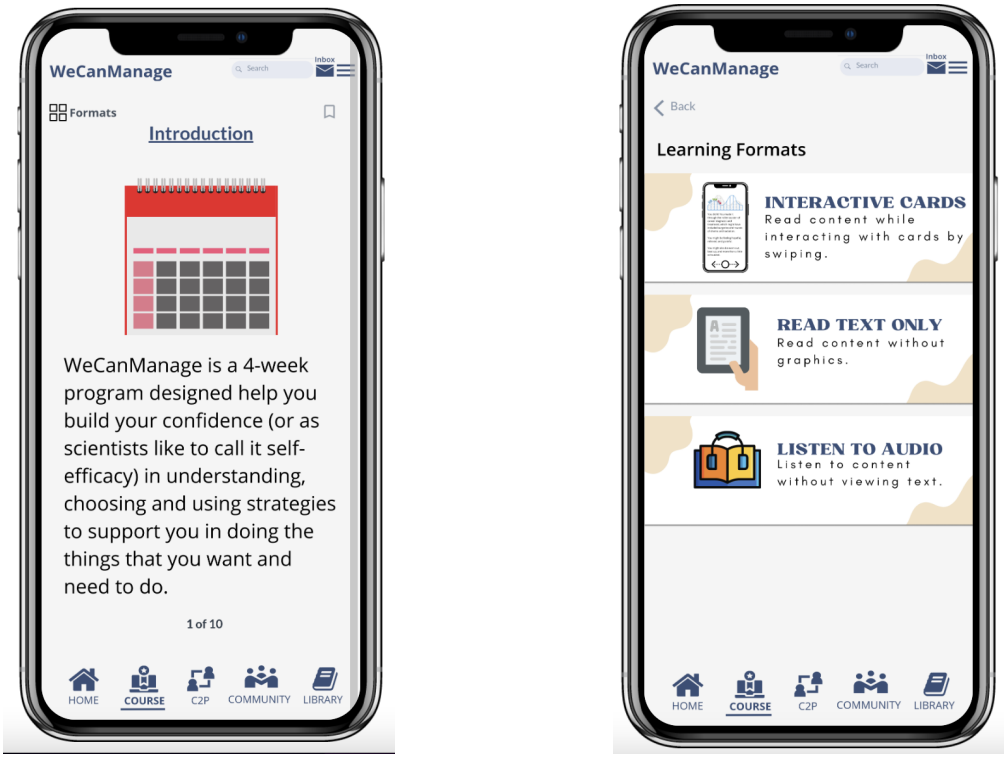
(A) (B) (C)



(D) (E)

Figure 1 shows (A) Home (B) Journey (C) C2P (D) Community (E) Library.

The Courses section provides cancer survivors with an educational intervention that works with them on dealing with the long-term effects of their newly acquired disabilities, through problem-solving, mindfulness, and self-advocacy. The content is designed to be a 4-week program where the user unlocks a series of micro-lessons divided into four modules. The four modules within WeCanManage (WeCanRelate, WeCanAdapt, WeCanBreathe, and WeCanSpeakUp) educate users with different methods to deal with the effects of post-cancer treatment in their daily life. The content of the course is provided in terms of either cards or videos with other format options users could switch to such as text-only or audio (Figure 2).



(A) (B)

Figure 2. Screenshots of the Course before heuristic evaluation (A) cards view (B) learning format screen

In addition, at the end of many of the daily sessions, there are interactive activities, such as reflections that feed to the library and knowledge checks (see Figure 3).

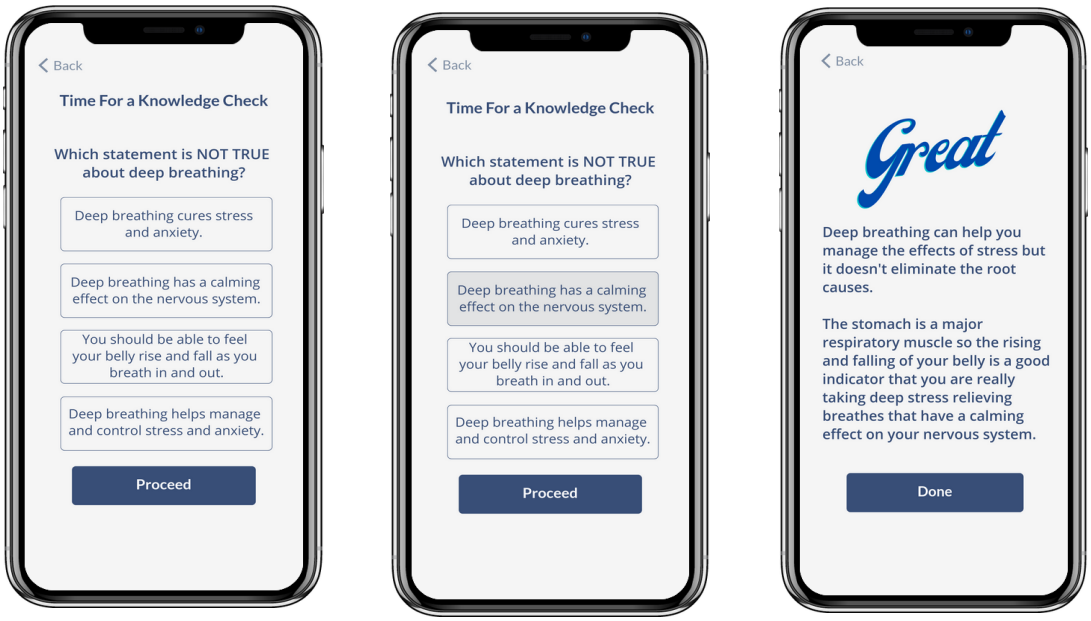


Figure 3. Screenshots of Knowledge Check screens

The community and C2P sections allow users to interact with other users in order to provide the opportunity to network and build a support system with people going through similar experiences. Lastly, the library section contains additional resources such as articles and factsheets targeting different parts of cancer survivors' potential needs. The different sections of the prototypes were designed through an iterative co-design method by the design teams and cancer survivors, who represented our targeted audience (Adler et al., 2022). We evaluated the high-fidelity prototype through two different methods: heuristic evaluation and usability testing.

Jakob Nielsen's 10 principles of heuristic evaluation (Nielsen, 1994) were used for the initial testing of the prototype. The ten principles are intended as a guide to help find usability issues within the user interface design to make it more user-friendly and intuitive (see Table 1). The prototype was given to 22 Northeastern Illinois University students taking an Introduction to Human-Computer Interaction course during a 1 hour and 15 minute class period in order to prepare a more polished prototype for end-users' usability testing. As part of the course, the students were given background knowledge of evaluating prototypes, including the 10 heuristic evaluation principles. We created three different sets of five tasks to be completed by the students during the session. The tasks included going through the introduction course module, switching to text and video fields, and filtering the users by a specific disability through the C2P page. During the session, due to the number of students, they were split into six groups, and therefore every two groups completed the same five tasks. Then used Maze, a testing platform that helps keep track of assessment details by keeping track of the path students took to complete the tasks and presenting questions regarding their experience. At the end of the sessions, groups had to complete a document stating which of the 10 heuristic principles were violated and the usability severity. The usability severity used a scale from 0 to 4, where 0 is not a usability problem and 4 is a usability catastrophe. Additionally, a set of questions were given to the students to collect their feedback and thoughts on the prototype's design. The questions targeted their likes and dislikes of the design, their thoughts on course modules, and the ease of changing the format of the content.

Ten Principles of Heuristic Evaluation
Visibility of system status
Match between the system and the real world
User control and freedom
Consistency and standards
Error prevention
Recognition rather than recall
Flexibility and efficiency of use accelerators
Aesthetic and minimalist design
Help users recognize, diagnose, and recover from errors
Help and documentation

Table 2. Ten Principles of Heuristic Evaluation

Usability testing was conducted on an improved prototype. Ten cancer survivors were given the polished prototype to receive feedback from our target audience which is essential as it allows for a better understanding of how the prototype is perceived by the people it's intended for. Participants were told sessions would be approximately 90 minutes. Sessions were held over Zoom and recorded. Participants shared their screens

for data collection. We used Ballpark, an online software to facilitate the usability testing for a prototype. Ballpark is an extension of Marvel that allows individuals to test a prototype through multiple methods. Participants were given eight tasks to complete (See Table 2). Participants gave a rating for satisfaction of ease and time taken per task out of a scale of 7, to evaluate the effectiveness of the current design and its features. After completing all eight tasks participants had time to 'think aloud' while playing with the prototype in order for us to observe their own interactions with the current design.

Task	Description
1	Go to the course and click on the WeCanRelate session. Read through all of the cards
2	Go to the course and click on the Introduction session. Switch to Text view to read all the cards at once using the eye symbol on the bottom left of the first screen of the module.
3	Go to the course and click on the Celebrating & Taking Stock session. Read through all the cards and then go to the reflection. Start "typing" your reflection and post it. Do you see your post accurately reflected?
4	Go to the course and click on the Straight Talk About Symptoms session. Read through the cards and follow the link to the library and the Understanding the Cancer Rehabilitation Team Fact Sheet.
5	Go to the course and click on the Deep Breathing session. Read through the content and complete the knowledge check. Did you get the correct answer?
6	Go to the course and click on the Body Awareness session and go through to the end of the module by watching the video.
7	Go to the Community Forum. Create a new post in the Open Discussion forum. Enter a title, select the community tag, enter text, and post your response.
8	Find the Connect to Peers (C2P) option and filter to narrow the search to people who are deaf or hard of hearing.

Table 3. Eight tasks given to usability testing participants.

Participants also completed the System Usability Scale (SUS), a short but reliable and valid 10-item questionnaire that measures usability (Brooke, 1996). We used the modified SUS by Bangor et al. (2008) which uses the more recognizable word "awkward" rather than "cumbersome." Additionally, open-ended questions on their likes and dislikes of the application were provided. Examples of the questions include, "How easy or difficult was it to see all the content on the screen?" and "What did you think of

the design of the course modules?". The data collected through usability testing and note-taking was analyzed to determine which areas of the prototype still need to be modified to fit cancer survivors' needs and wants.

RESULTS

Results of Heuristic Evaluation

We analyzed the heuristic violations that were found and their severity. The highest severity rating found was a three, as shown in Figure 4. Flexibility and user control and freedom were the most frequent heuristic violations reported, mainly due to navigation problems within the prototype, such as missing back buttons, accessibility features being hard to find, and too many options in the navigation bar. Suggestions were also brought up such as having a FAQ page, increasing the font size, different formats to display information in the modules, a way to reach out to the creators or admins, and including a walk-through or how-to page.

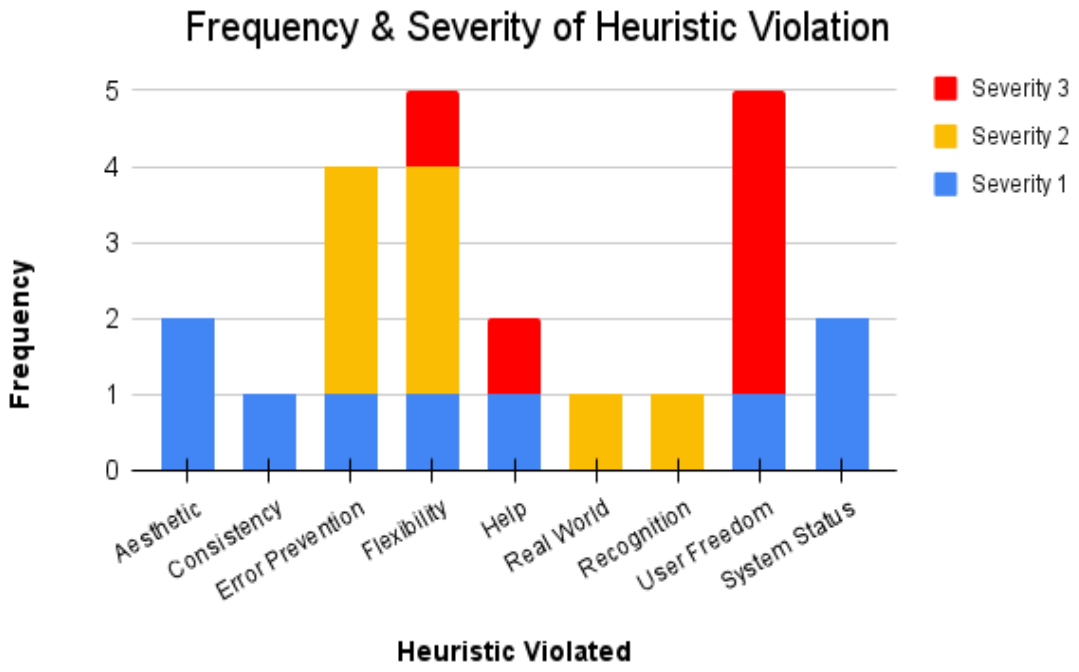


Figure 4 shows a graph displaying the frequency and severity of heuristic evaluation found by the students.

Modifications based on Heuristic Evaluation

The result of the heuristic evaluation led to improvements within the user interface of the prototype. We improved the prototype by creating a help guide (Figures 5a and 5b) to address concerns brought up by participants of potential confusion regarding certain features and sections of the prototype. The method for accessing the accessibility features, such as audio and text, was modified as some groups reported difficulties finding the features (Figures 5c and 5d). We increased the font size on multiple screens, as participants had trouble reading certain small text through the prototype. Lastly, participants expressed navigation difficulties in certain screens which

were addressed through additional back buttons in certain screens and swiping through the modules being replaced with arrow buttons for a smoother and easier transition.

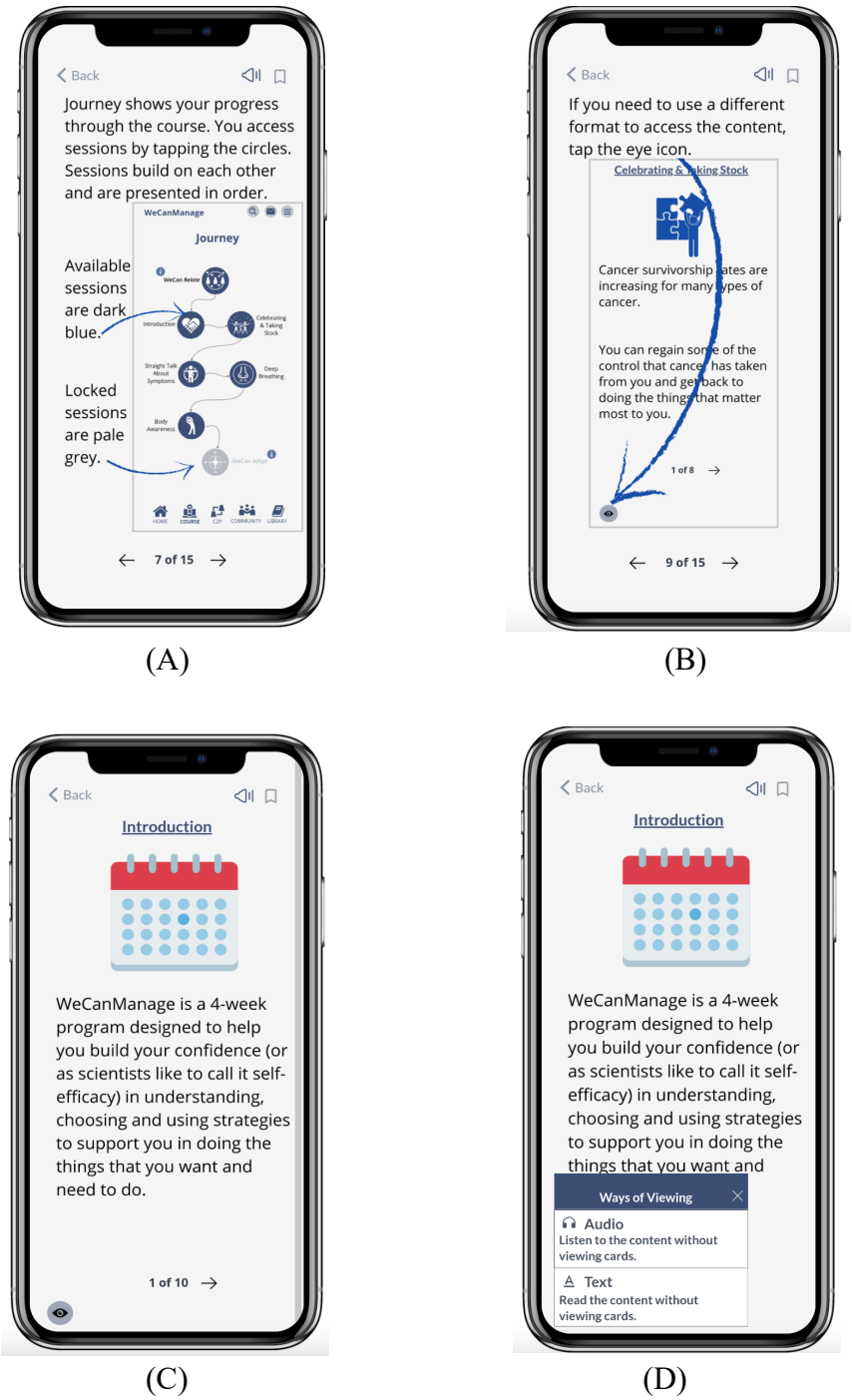


Figure 5. Updated prototype screens after heuristic evaluation

Results of Usability Testing

We conducted usability testing on 10 cancer survivors with disabilities to determine the overall usability of the current prototype from our intended audience. Usability scores and task completion results showed an overall positive reception to the design of the prototype. To calculate the SUS scores, 1 is subtracted from the raw score of the odd-numbered items (those items phrased in a positive way), and the raw score of the even-numbered items (those items phrased in a negative way) is subtracted from 5. The sum of the scores is multiplied by 2.5 to reach a "standardized SUS Score" which is out of 100, where 68 is considered average usability (Sauro and Lewis, 2016) and above 80.3 is considered an A grade, the top 10% of scores (Sauro, 2011). We had an average SUS score of 81, therefore, our prototype's usability is considered with a grade of A.

In order to examine the satisfaction of participants, we asked them to rate their satisfaction with ease of completion and time taken for each task on a scale of 7. Table 3 showcases the average of these two measurements. Overall participants had high satisfaction rates, though the numbers were lower for task 2 (finding the eye icon to change the accessibility format), task 7 (creating a post in the community forum), and task 8 (using the filter in Connect to Peers).

Task	Average Satisfaction per task	Average satifaction for time of task
Task 1	6.5	6.4
Task 2	5.7	5.9
Task 3	6.6	6.5
Task 4	6.5	6.2
Task 5	6.7	6.3
Task 6	6.8	6.6
Task 7	5.2	5.5
Task 8	5.8	5.7

Table 4. shows the average satisfaction for ease of completion per task (out of 7) and the average satisfaction for the amount of time taken per task (out of 7).

In order to determine the effectiveness of the prototype, we had two independent coders check whether participants:

1. Completed the task without help quickly (C)
2. Completed the task without help though it took a little longer (L)
3. Needed help to complete task (H)

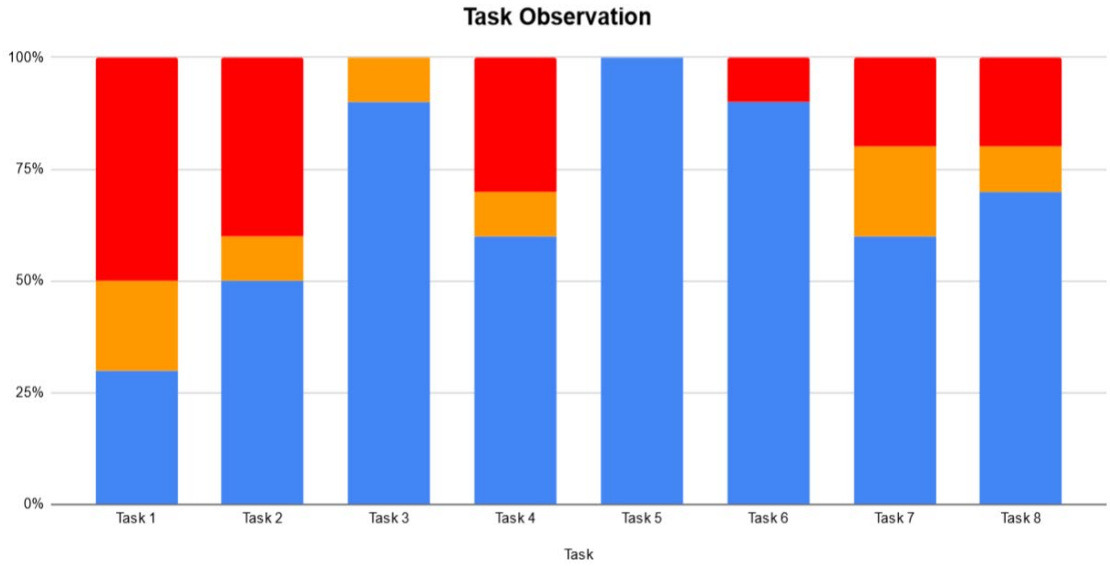


Figure 6. Graph displaying the frequency of H, C, and L ratings given to participants as they completed a task

The percentage of agreement between the coders was 87.5%. Any differences were resolved with discussion. Overall participants generally completed their task with no issues with 17 out of 80 (21%) cases needing help to complete it (See Figure 6). Task 1 demonstrated a slight learning curve with participants having trouble locating the correct module which resulted in help needed to complete the task. However, this issue was not apparent after the first task. Task 2 showed participants had trouble switching the format of the card (to text view) through the eye symbol as they had trouble locating the button. In task 4 some participants had difficulty clicking on the correct resource within the library, while Task 7 and Task 8 showed participants struggling to navigate both the community and C2P section due to certain text and icons being too small or ambiguous.

Based on observations made during the sessions, we found that participants had issues concerning (1) accessibility such as font sizes and icons being too small, particularly the navigation arrows on the cards, top navigation bar, and the eye icon, (2) some confusion regarding navigating the community page when creating new posts (3) finding and navigating the filter option within the C2P page (4) wanting an easy way to return to the help guide.

In our open-ended questions, participants reported on their likes and dislikes of the prototype and its design. Participants expressed positive opinions on the design and content of the modules with many of them finding them helpful and insightful. The video located within one of the modules was well received and some expressed wanting additional videos. The purpose of the community section was well-liked with many enjoying having a place where they can express themselves freely with others who have gone through similar experiences and it being a way for users to help each other.

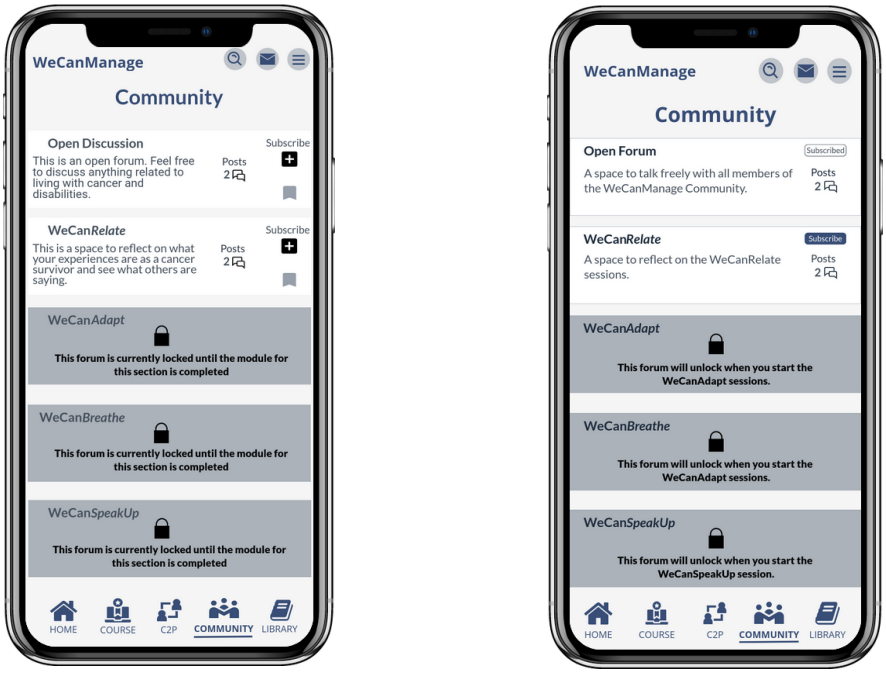
The library resources were found to be informative and useful with their coverage of many different topics. The guide for the prototype was received well with 80% of participants rating it very helpful or extremely helpful. In terms of dislike and concerns, participants pointed out the robotic voices used in the audio format for the modules, the design of the community section which had caused confusion throughout the task, the C2P filter button being hard to find, certain font within the design being small and hard to read, the eye and arrow icons within the modules being too small, and wanting a more accessible way to return to the guide. Overall, the participants were able to provide useful data regarding the prototype design which was then used to further improve upon it and address any issues found. Direct quotes by participants included:

- “Great app, it would have been very helpful to me when I was just out of treatment. I know I'm not alone feeling this way after treatment. So whatever, however, it helps, like the library or communicating with people.”
- “I want to see the whole thing work! I know that this is a prototype, but I want to see more!”
- “Even though I'm not very comfortable with technology… I don't think that this would be difficult for me. I think there'd be a real fast learning curve. I felt good and positive when I realized I had learned something, and I could just click on it now without having to think about it.”

Modifications Based on Usability Testing

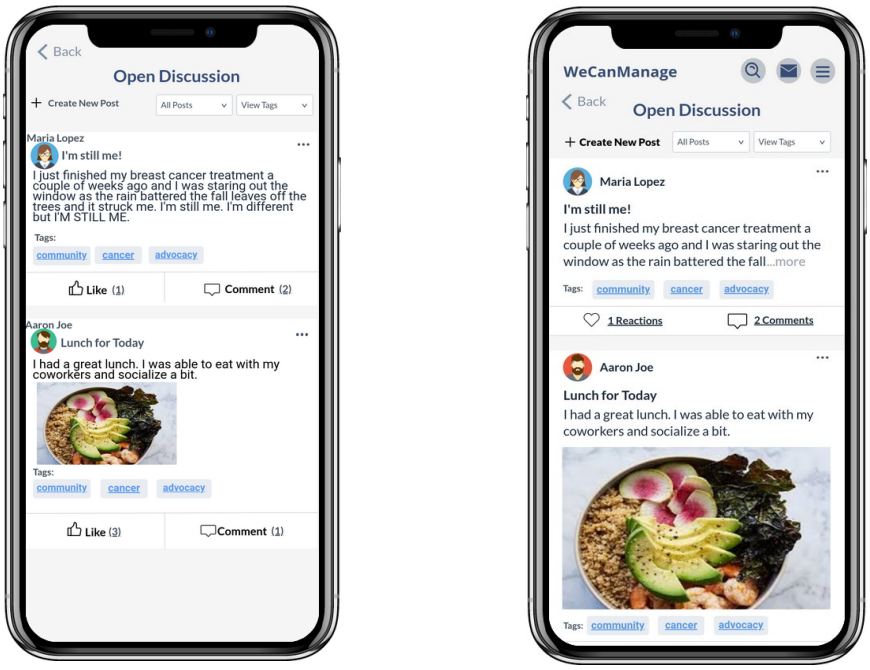
We modified the prototype based on the results of usability testing. To address accessibility concerns regarding certain icons and text being hard to see or read we enlarged the sizes of the navigation icons, eye icon, arrows within the cards, and top nav bar. Fonts were increased or bolded throughout the application for easier reading, such as the “create new post” button in the community. The design of the community and forums were modified with text and margins being increased to provide a cleaner and more concise design. Additionally, the subscription button was redesigned to showcase its purpose and limit confusion as participants had the most trouble navigating this section of the prototype (See Figures 7 and 8). The C2P filter was modified in terms of accessibility for our audience by increasing its size since there was trouble locating it. A way to return to the guide provided in the first module will be added to the hamburger icon located on the top navigation bar as participants expressed wanting a more accessible way to return to the guide. Feedback from usability testing led to the wants and needs of our targeted

audience being integrated into the prototype. Overall the WeCanManage prototype was improved in terms of accessibility, efficiency, and usability for our intended users.



(A) (B)

Figure 7. Modifications made to the Community page based on the usability results: (A) Before (B) After



(A) (B)

Figure 8. Modifications made to the Open Discussion forum's design based on the usability results: (A) Before (B) After

DISCUSSION

Cancer treatment can lead to long-term disabilities that affect a survivor's overall quality of life which is amplified by the lack of resources available post-cancer treatment. As such, it is important to provide support and resources that fit the needs of cancer survivors. Cancer is tied as the second most frequently evaluated health app, right behind mental health (Maramba et al., 2019). As such, receiving feedback is vital in ensuring the application is usable and fits the specific needs and wants of the users. This feedback can help improve the design, benefiting future users and overall satisfaction with the application (Santesteban-Echarri et al., 2019). We designed a high-fidelity prototype for

an mHealth application, WeCanManage, to help empower cancer survivors with disabilities to self-manage the long-term effects of cancer and its treatment. The prototype was then polished through both heuristic evaluations with 22 university students studying Human-Computer Interaction and usability testing on 10 cancer survivors. Multiple methods were used for usability testing including task completion, open-ended question, think-aloud, and the System Usability Scale as such methods are standard in usability testing (Maramba et al., 2019).

The results were overall positive with the cancer survivors liking the application's purpose, features, and design. The prototype received an SUS score of 80.3 which is in the top 10% of scores and is considered an A grade. Average satisfaction per task completion and time taken were high with an average score of 6.2 and 6.1 out of a scale of 7. Participants pointed out a few design issues which included: 1) font sizes and icons being too small, such as the navigation arrows on the cards, top navigation bar, and the eye icon, (2) some confusion regarding navigating the community page when creating new posts (3) finding and navigating the filter option within the C2P page (4) wanting an easy way to return to the help guide. Complicated or unclear navigation is a common issue with mHealth prototypes, for example usability testing conducted for eClinic prototypes aimed at youth with mental health issues found users had trouble with navigation finding certain parts leading to complications such as booking appointments, which is similar with our navigation regarding posting in the community page (Ospina-Pinillos et al., 2019). The desire for simpler navigation is found in other mHealth studies (Beatty, 2021; Santesteban-Echarri et al., 2019) . Simple and accessible navigation is significant in positive user experience. We found that clear text and font is important for

accessibility. Similarly, Charmian Reynolds' study on testing the usability of multiple self-management pain applications found the application with the lowest score resulted from unclear text and font which made information difficult to read which impacted user experience. As such, making sure text is clear is vital for a positive user experience.

The Feedback collected and changes made to the design highlighted important main takeaways when designing a mHealth application which includes the importance of accessibility when designing an application for cancer survivors, the addition of help features, and the inclusion of social features and concrete to prevent isolation and the feeling of being alone through this journey.

Limitations of the testing included a limited number of available participants for usability testing. The SUS questionnaire's results are usually derived from 12 or more participants (Lewis, 2018; Tullis, & Stetson, 2004), however, we were only able to recruit 10 participants that represent our target audience. We also faced some technical issues with Zoom leading to difficulties and communication issues with potential participants.

The high-fidelity prototype for our mHealth application, WeCanManage, was improved and polished through two cycles of testing, heuristic evaluation, and usability testing. Future work for the project includes handing off the prototype for full implementation of the application and feasibility testing.

BIBLIOGRAPHY

1. Adler, R. F., Morales, P., Sotelo, J., & Magasi, S. (2022). Developing an mHealth App for Empowering Cancer Survivors With Disabilities: Co-design Study. JMIR Formative Research, 6(7), e37706.
2. Alturki, R., & Gay, V. (2017, September). Usability testing of fitness mobile application: methodology and quantitative results. In *7th International Conference on Computer Science, Engineering & Applications* (pp. 97-114).
3. Bangor A, Kortum P, Miller J (2009) Determining what individual SUS scores mean: adding an adjective rating scale. Usability Study 4:114–123
4. Beatty, L., Koczwara, B., Butow, P., Turner, J., Girgis, A., Schofield, P., Hulbert-Williams, N. J., Kaambwa, B., & Kemp, E. (2021). Development and usability testing of a web-based psychosocial intervention for women living with metastatic breast cancer: Finding My Way-Advanced. *Journal of cancer survivorship: research and practice*, *15*(3), 403–409.
5. Børøsund, E., Mirkovic, J., Clark, M. M., Ehlers, S. L., Andrykowski, M. A., Bergland, A., ... & Nes, L. S. (2018). A stress management app intervention for cancer survivors: design, development, and usability testing. *JMIR formative research*, *2*(2), e9954.
6. Brooke J (1996) SUS-A quick and dirty usability scale. In: Usability evaluation in industry, pp 189–194
7. Derks, Y. P., Klaassen, R., Westerhof, G. J., Bohlmeijer, E. T., & Noordzij, M. L. (2019). Development of an ambulatory biofeedback app to enhance emotional awareness in

patients with borderline personality disorder: multicycle usability testing study. *JMIR mHealth and uHealth*, *7*(10), e13479.

8. Donald, M., Beanlands, H., Straus, S. E., Smekal, M., Gil, S., Elliott, M. J., ... & Hemmelgarn, B. R. (2021). A web-based self-management support prototype for adults with chronic kidney disease (my kidneys my health): co-design and usability testing. *JMIR formative research*, *5*(2), e22220.
9. Fuller-Tyszkiewicz, M., Richardson, B., Klein, B., Skouteris, H., Christensen, H., Austin, D., & Ware, A. (2018). A mobile app–based intervention for depression: end-user and expert usability testing study. *JMIR mental health*, *5*(3), e9445.
10. LaMonica, H. M., Davenport, T. A., Burns, J., Cross, S., Hodson, S., Veitch, J., & Hickie, I. B. (2019). Technology-enabled mental health service reform for open arms–veterans and families counseling: participatory design study. *JMIR Formative Research*, *3*(3), e13662.
11. Lewis, J. R. (2018). The system usability scale: past, present, and future. *International Journal of Human–Computer Interaction*, *34*(7), 577-590.
12. Martinez, W., Threatt, A. L., Rosenbloom, S. T., Wallston, K. A., Hickson, G. B., & Elasy, T. A. (2018). A patient-facing diabetes dashboard embedded in a patient web portal: design sprint and usability testing. *JMIR human factors*, *5*(3), e9569.
13. Maramba, I., Chatterjee, A., & Newman, C. (2019). Methods of usability testing in the development of eHealth applications: A scoping review. *International journal of medical informatics*, *126*, 95–104.

14. Morey, S. A., Stuck, R. E., Chong, A. W., Barg-Walkow, L. H., Mitzner, T. L., & Rogers, W. A. (2019). Mobile health apps: improving usability for older adult users. *Ergonomics in Design*, *27*(4), 4-13.
15. National Cancer Institute. (n.d.). *Cancer Statistics*. Retrieved February 23, 2022, from https://www.cancer.gov/about-cancer/understanding/statistics
16. National Research Council. (2005). *From cancer patient to cancer survivor: lost in transition*. National Academies Press.
17. Nielsen Jakob. 1994. "Heuristic Evaluation" In Usability Inspection Methods, edited by Nielsen Jakob and Mack Robert L., 1st ed, 25–62. New York: Wiley.
18. Ospina-Pinillos, L., Davenport, T., Diaz, A. M., Navarro-Mancilla, A., Scott, E. M., & Hickie, I. B. (2019). Using participatory design methodologies to co-design and culturally adapt the Spanish version of the mental health eClinic: a qualitative study. *Journal of medical Internet research*, *21*(8), e14127.
19. Pergolotti, M., Deal, A. M., Lavery, J., Reeve, B. B., & Muss, H. B. (2015). The prevalence of potentially modifiable functional deficits and the subsequent use of occupational and physical therapy by older adults with cancer. *Journal of Geriatric Oncology*, *6*(3), 194–201
20. Markus Pohl (2017). 325,000 mobile health apps available in 2017 – Android is now the leading mHealth platform. Research2Guide.
21. Reynoldson, C., Stones, C., Allsop, M., Gardner, P., Bennett, M. I., Closs, S. J., ... & Knapp, P. (2014). Assessing the quality and usability of smartphone apps for pain self-management. *Pain medicine*, *15*(6), 898-909.

22. Santesteban-Echarri, O., Tang, J., Fernandes, J., & Addington, J. (2019). Development and usability testing of SOMO, a mobile-based application to monitor social functioning for youth at clinical high-risk for psychosis. *Digital Psychology*, *1*(1), 4-19.
23. Sauro, J. (2011). Measuring usability with the System Usability Scale (SUS). Retrieved April 16, 2023, from http://www.measuringu.com/sus
24. Sauro J, Lewis JR (2016) Quantifying the user experience: practical statistics for user research. MorganKaufmann, Cambridge, MA
25. Tullis, T. S., & Stetson, J. N. (2004, June). A comparison of questionnaires for assessing website usability. In *Usability professional association conference* (Vol. 1).
26. U.S General Service Administration (2022). What & Why of Usability. Usability.gov
27. Wasil, A. R., Gillespie, S., Schell, T., Lorenzo-Luaces, L., & DeRubeis, R. J. (2021). Estimating the real-world usage of mobile apps for mental health: development and application of two novel metrics. *World psychiatry : official journal of the World Psychiatric Association (WPA)*, *20*(1), 137–138.
28. Woods, L., Cummings, E., Duff, J., & Walker, K. (2017). Design thinking for mHealth application co-design to support heart failure self-management. In *Context sensitive health informatics: Redesigning healthcare work* (pp. 97-102). IOS Press.