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Category	Min	Max	Chosen
Requirement Analysis and Design	0	20	20
Theoretical Analysis	0	25	0
Experiment Design and Execution	0	20	0
System Development and Implementation	0	20	20
Results, Findings and Conclusions	10	20	10
Aim Formulation and Background Work	10	15	10
Quality of Paper Writing and Presentation		10	10
Quality of Deliverables		10	10
<u>Overall General Project Evaluation</u> (<i>this section allowed only with motivation letter from supervisor</i>)	0	10	0
Total marks	80	80	

Designing a System with a NPO in a Sensitive Context

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ABSTRACT

This is a software engineering project with aspects of research rooted in Human Computer Interaction (HCI). It discusses the methods used to design a system alongside a non-profit organization (NPO) in a sensitive context. It explored conducting field work through online channels in a global pandemic, as well as how a complete system can be created with minimal resources. This project's development was done in three phases, in which the researchers interviewed two different participant groups in each phase. The staff of the organization, and donor mothers from the organization. The deliverable at the end of the three development phases was a system consisting of a donor facing mobile application, an organization facing web application to update the donor application, and a back-end to connect and provide functionality to the two front-end applications.

KEYWORDS

Co-Design, User Centric Design, Human Milk Bank, breastmilk, non-profit organization, front-end, back-end, Human Computer Interaction, Information Communication Technologies for Development

1 INTRODUCTION

This project is a collaboration with a non-profit organization, a breastmilk bank in Cape Town, South Africa. The aim is to design a system with the NPO, *Milk Matters*¹, that will improve the experience of breastmilk donors. Whenever a system is mentioned in the context of this paper, it refers to a donor facing mobile application, that is controlled by a web front-end interface on the NPO's side, with a back-end providing connectivity and middle tier functionality. This project is a continuation of Wardle et al. [20] project done in 2016, where a mobile application was co-designed alongside donor mothers from Milk Matters.

This project will contribute to HCI and Information Communication Technologies for Development (ICT4D), as it

discusses methods of doing field work during a global pandemic (COVID-19) with a sensitive demographic. This project also demonstrates the ability of a small team of students to design a complete system in the context of an NPO, with limited resources and limited time.

This paper will provide the background and related work required to understand its entirety. The structure of this paper is as follows: a detailed outline of the methods for requirement gathering, development and testing. Then the findings from the requirement gatherings and an analysis splitting those findings into functional and non-functional requirements. This will allow the reader to understand the system design section that follows it. Then a findings section for the whole project, the discussion and analysis, and conclusions.

2 BACKGROUND

2.1 Milk Matters

Milk Matters is a community-based, non-profit, human breastmilk bank based in Cape Town. Their organization's goal is to distribute pasteurized donor milk to premature and vulnerable babies in Neonatal Intensive Care Units (NICUs) [18]. Due to a constant need for donor milk [16, 17], it is important for Milk Matters to retain their donors and ensure a high return rate of old donors. Milk Matters is currently operating with three staff members, which means they must be efficient with their time to complete all required activities.

The World Health Organization (WHO) defines breastmilk as a vital medical resource and the best source of nutrition for infants [19] and health professionals recommend human milk banks as the best breastmilk donation method [13]. This makes Milk Matters a crucial organization as it works as an off-site donation based human milk bank. Mothers go through a screening process to become donors, and when they receive their donor number they can start dropping off donations at depots located around Cape Town. The donations are collected by Milk Matters staff and volunteers from the depots.

¹ <http://milkmatters.org/>

Wardle et al. [20] worked with Milk Matters and donor mothers in 2016 to co-design a donor facing mobile application for Milk Matters' donors. The features provided by the mobile application are: a depot locator where mothers can find a depot closest to them, education articles approved by Milk Matters, the organization's news and events feed, a pre-screening questionnaire, donation tracking and visualizations, a way to contact Milk Matters, and security for sensitive information in the app [20]. This application and research was used as the starting point of this project, and also used to build an improved system for Milk Matters.

2.2 Related Work

Wardle et al. and Balaam et al. provide techniques for designing with mothers and discuss the importance of designing for and with breastfeeding mothers, and the importance of including their baby in the process [1, 20]. Key factors of co-designing with mothers are: interrupted interactions due to small children, single-handed interaction as mothers are busy holding their baby, elements that might distract babies in application design, empowerment of the mothers through feedback and choice as they like to have a sense of accomplishment and control, and positive reinforcement [20].

Literature around new mother's use of technology draws parallels with themes that breastmilk donors experience [3,17]. Dizon discusses the need to improve confidence as a mother, the sense of isolation mothers feels with newborn babies, the longing to belong in a community and the need to be more than 'just' a mother [3]. This is beneficial to our project, as understanding new mothers and what they look for in technology can help us understand the behavior of donor mothers.

Persuasive technologies in a breastmilk donation environment can be harmful. To distance the techniques used from persuasion, I used the term "Affirming technology", which is the use of persuasive technology in a sensitive context. To ensure this, we follow the literature around persuasion which shows that to remain ethical the user should be greatly involved in the design [1]. We do not want mothers to feel forced to donate, or to feel inadequate with the amount they donate. Therefore, we will use Affirming technologies to give mothers motivation to donate milk, as well as assert to them that every drop is valuable. We used two design paradigms to better understand persuasive technologies: Fogg's Behavioral Model (FBM) and Persuasive Social Actors (PSA) [5, 6, 14]. FBM is a psychological model that denotes the three factors that control whether a behavior takes place. The factors are motivation, ability, and triggers [5]. The PSA paradigm shows how a computer can act as a social actor, which can persuade through different methods, including rewarding people with positive feedback [6].

Milk Matters is a NPO in a health care context, and due to that they have regulations to follow to ensure their donors are protected. This can cause clashing requirements between donors and the organization when the donors want something that is not feasible. The work done by Melissa Ho on engaging conflicting stakeholder requirements [7] is valuable in this project as it

highlights the importance of researchers to position themselves and their designs in a way that accounts for all stakeholders, not only the primary user or stakeholder. This paper also discusses the limitations brought by not engaging all stakeholders, in this case a loss of information [7].

When analyzing the feedback received during the research, Nicola Dell's research on participant response bias in HCI [2] will be helpful. In this paper she discusses how participants are more likely to prefer a technological artefact when they are aware it was designed by the interviewer. 2.5x more likely [2], even when the alternative is the same. They are more likely to prefer the artefact even if the alternative is better. This is the case in this project as the interviewees are designing the artefacts.

3 DESIGN AND IMPLEMENTATION

To successfully complete this Software Engineering project, we used a User-Centered Design (UCD) approach to adhere to the sensitive nature of the breastmilk donation and to balance the requirements between stakeholders. Co-Design elements were used with Milk Matters' staff and donors to ensure the requirements from both sides are satisfied while avoiding any problematic aspects that could have been incorporated.

The initial requirements gathering resulted in a project comprising of three components. An updated donor-facing mobile application which was developed by Dino Bossi, a Milk Matters-facing web application to allow for dynamic content in the donor app which was developed by me, Gustavo Amicis M. de Souza Mendes, and a back-end database to give communication, support and functionality to the front-end applications design by Gerhard Serton.

This project required human participants to partake in interviews, and due to the sensitive demographic, as well as the COVID-19 pandemic, the team had to ensure the research was performed ethically. All research was done online in consideration of the pandemic, as it would have been unethical to try and pursue field work. Participants' were kept anonymous and their information kept private. The team maintained close communications with the project supervisor to ensure the research considered all ethical concerns. Ethical clearance for this project was approved by the UCT Human Research Committee [15].

An initial communication was sent by Milk Matters to their current donor mailing list when ethics clearance was received. This included a brief summary of the project, a link to the initial survey, and the informed consent form. Before every online interview, the informed consent was reiterated to ensure participants were still comfortable, and willing to continue with the process. All interviews were video recorded, and transcribed, permission to do this was requested before turning on the recording each time.

3.1 Project Management

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An agile methodology was used to meet the constant changing requirements of the project, as well as to keep the users engaged with the design process through presenting them with deliverables. In the development phase from the interactive prototype to the working system, the team changed to a Scrum approach to ensure the development was done in time. We would have daily meetings at night where we discussed the changing requirements of the project. We did Scrum check-ins in the mornings. The check-ins would highlight what we have done, what we plan on doing that day, and any difficulties we could foresee in completing that day's tasks.

Throughout the project we had regular check-ins with our primary stakeholders - the project supervisor and the NPO partners. The team had weekly meetings via *Microsoft Teams*² with the project supervisor, as well as emails, and *WhatsApp*³ communication. Once ethics clearance was obtained, the NPO partners were also frequently contacted on WhatsApp and emails to ensure the project was going on the right track and the requirements stayed relevant and useful. The team sometimes had impromptu meetings with the Milk Matters' staff to discuss complications or clarify any confusion around desired features.

All the meetings with participants of the research were done through *Jitsi*⁴. Jitsi was chosen due to its ease of use, it does not require prior installation as it is a web service. This meant it was convenient for the donor mothers and Milk Matters' staff as they did not need to prepare before meetings, besides for following the link sent to them via email.

*Git*⁵ version control was used to collaborate among group members and maintain code. This was the easiest tool to use to coordinate work among the three group members, as it allows for the team to have updated code as often as it is pushed onto the repository and be notified of when code has been added or edited. Due to the nature of the application and web-application, there was a high-level of code reusability available between the two, which Git facilitated.

3.2 Development and Testing

The project's development can be discussed in three distinguished phases that followed an iterative process which resulted in a deliverable at the end of each phase. A User Centric approach with elements of Co-Design allowed us to make design decisions based on the requirements of the donor mothers, but maintaining those requirements in line with Milk Matters. It is important to emphasize that the Milk Matters facing web application would get most of its requirements from the mobile application, as its purpose is to provide the content of the mobile application.

Therefore, it is necessary to discuss the mobile application in the point of view of Milk Matters to understand the project.

The first phase of development was the requirement gatherings phase. This phase consisted of an initial survey and one-on-one interviews with each of the participants of the research. This phase resulted in an interactive wireframe prototype of the mobile application and web application. The second phase was an evaluation and feedback phase, where the donor mothers gave feedback on the donor mobile application and the Milk Matters' staff gave feedback on the web application. The deliverable for phase two was a working system of the front-end and back-end applications. Phase three was an evaluation of the working system, the same as phase two, and it resulted in a refined system ready for deployment based on the feedback of participants.

The three interviews were performed in pairs, one team member took the role of interviewer, and the other scribed. The scribe would record the interview, and take notes, while having their camera and audio turned off to make the participant feel as if it was only one person in the call, as it was a one-on-one interview format. There was a total of four donor mothers and two staff members who participated in the interviews. The pairs and roles of who performed the interviews remained the same for individual participants to create familiarity, besides for a few exceptions. I conducted all the interviews with the Milk Matters staff, Staff Member #1 & #2, as I was in charge of development of the NPO facing application. I also participated in the interviews with Donor #1 and Donor #2. The analysis of all the interviews were done collaboratively between the three project members.

3.2.1 Initial Survey

The initial survey was to get to know the donor mothers better, with questions about being a donor, working with Milk Matters, general technology and social media use, and some questions more specific to the donor facing application. The survey was sent to Milk Matters to edit and approve, and then Milk Matters sent it to the mailing list of current donor mothers along with an invitation to participate in the research and an informed consent form. All the donor mothers who Milk Matters contacted could respond to this survey. The survey was especially useful for the mothers who could not participate in the research but wanted to give their input. The survey consisted of short answer questions, open-ended questions, radio buttons and check boxes.

3.2.2 Initial Interview

Initial requirement gathering interviews were held with the two different participant groups, Milk Matters and Donor Mothers. These interviews took place on Jitsi and were scheduled through email to be very flexible in terms of time as we wanted to give the participants freedom to choose a convenient time. The interviews were semi-structured as to keep to the thirty to forty-five-minute time slot. The interviews started with a small introduction to the team and the project and followed up with an explanation of the ethics form, and consent to record the interview.

² <https://www.microsoft.com/en-za/microsoft-365/microsoft-teams/group-chat-software>

³ <https://web.whatsapp.com/>

⁴ <https://meet.jit.si/>

⁵ <https://github.com/>

Interview questions were tailored towards the two different groups. The donor questions were aimed towards finding out information about themselves and their experience with milk donation, their donation habits, general maternity, smartphone use, privacy concerns, and their opinions about Milk Matters and the idea of an application. These questions were kept broad as to have more input from the user and understand who we were designing for.

The interviews with the Milk Matters staff took the same approach, however, the aim of the questions was slightly different as Milk Matters had worked on the 2016 project, and already had a lot of initial requirements laid out. The interview starts off with some warm-up questions to find out more about the staff and their roles in Milk Matters. Then questions about their donors and donor engagement were asked. The last half of the interview was to go through the donor application and Milk Matters application.

3.2.3 Wireframe Evaluation

For phase two, interactive wireframes were created using *Moqups*⁶, most of the functionality came from the 2016 application, and due to time constraints only some of the phase one interview requirements were included. Initially, these wireframes were supposed to be low-fi prototypes, in the form of a paper prototype. Two prototypes were created, one for the donor facing application and one for the Milk Matters facing application.

The interviews were performed on Jitsi, and were divided into two sections, the first half was the wireframe evaluation, and the second half was feedback on the wireframe, and the process. The interviews started off with a review of the consent form and followed onto an introduction of how the interview process was going to work. The interviewer would share their screen with the wireframe on it, and ask the participant to vocalize their actions, such as where they would click, what input they would enter, and what they were thinking. This was done with individual tasks given to them which would test how intuitive the design of the application is, and would allow the participants to see all the functionality in the app. The donors had 12 tasks to complete, which started off with creating an account, and ended with suggesting an article. The Milk Matters interviews consisted of 20 tasks, from login into the Milk Matters web interface, to deleting a news article.

The feedback half of the interview consisted of questions to understand how the participants would use the applications, any difficulties they had in the tasks, questions on what functionality they liked, and general feedback. For the Milk Matters feedback, we also asked whether there was any functionality or language in the wireframe that could negatively impact donors. The data gathered in this phase was used to an almost finished version of the system.

⁶ <https://app.moqups.com/>

3.2.4 System Evaluation

The last phase of development took the same approach as phase 2; evaluation and feedback interviews of nearly the final version of the system. The donor facing application was evaluated using an Android phone emulator in screen share. The donors were given tasks to complete and dictated their actions to the interviewer to complete them on their side. The Milk Matters web application was loaded on *Google Chrome*⁷. They went through the same process as donors.

After the application evaluation part of the interview, participants were asked to answer some questions for feedback. These questions covered the functionality, design, and usability of the application, what the user liked and disliked, what difficulties they had using the application and completing tasks, if they would use the apps and what benefits they foresaw from its use, and what they thought of the whole design experience. Milk Matters' staff were asked additional questions on whether this system could be applicable in the context of non-governmental organizations (NGOs) in general, if training to use the web app is necessary, how their expectations were met, and the future of the application. This feedback was used to refine the application.

The result of this whole process, and the end of phase three, is a system which consists of a donor mobile application, a web application for Milk Matters to update content in the donor application, and a back-end to support the data and authorization functionality for both applications.

3.2.5 User Centric Design

This project used an UCD approach, with elements of Co-Design. We only applied co-design to more crucial functionality which had sensitive connotations, to ensure it did not conflict with any concerns Milk Matters may have had with this project. This included functionality with sensitive data, security and privacy, and functionality which could affect how Milk Matters is seen or how the donor mothers feel. For the rest of the application, we would gather the requirements for the functionality, apply it as we envisioned it, and then get feedback to improve it or change it. Communication was a key aspect of this project's success.

3.2.6 Testing

The time constraints for this project did not leave enough time to write structured unit tests for the system. The testing done was by analyzing use cases of the applications and manually testing with different inputs, with inputs which could cause bugs, manually adding, deleting, and editing the database, and using print statements in the code to see how the different features behaved with different inputs. Input validation was incorporated into the applications, and that was also a form of testing. Lastly, performing the tasks given to participants was also a way to test.

⁷ <https://www.google.com/chrome>

4 SYSTEM REQUIREMENTS

4.1 Requirement Findings

The first two phases of this project gathered data from 13 different participants. 7 participants from the online survey, 4 donor mothers and 2 Milk Matters' staff members who participated in interviews.

The survey response showed the distribution of smartphones in donors, 3 participants used iPhones, 3 participants used Android smartphones, and 1 used both. In terms of the 4 donor mothers, 3 of them used iPhones. The different operating systems for the donors' smartphones was mentioned by Staff Member #1 in Phase 1, "we had a few people who were definitely a little sad because they had Apple phones so they couldn't try it out." Regarding the original application. Donor #3 mentioned in phase 1 that "I would have used it" referring to the old application but couldn't because she had an iPhone.

Findings from the survey responses showed the donors valued the original functionality of the mobile application, as each feature had at least 4 votes. This is shown in Figure 19. The favorite seemed to be Donation Tracking, as every respondent voted on it. All four donors who participated in the interviews showed great excitement for this feature. Donor #1 mentioned it as her favorite feature, "It would be nice to track how much you've donated... because it's very blind at the moment."

Staff Member #1 and Staff Member #2 agreed with keeping and improving on the original functionality, however, they both highlighted that not being able to update information on some of the features was a problem. Staff Member #1 responded in her phase 1 interview, "if we can update the information... extremely useful" when asked about keeping the features, and Staff Member #2 highlighted that "the depot part... the editing of the depot details will be very easy, that would be my favorite" after the prototype evaluation in phase 2. She also mentioned being able to edit news and events would be helpful, as "I am afraid I miss something so streamlining would be great" referring to communication.

The Milk Matters' staff was excited with the proposed functionality discussed in phase 1 but showed some concern around it. Staff Member #1 said the following when asked about allowing donors to suggest articles for the application: "I like that idea. We have to be careful what expectations we create for the mothers... we can offend them by not putting it on." This was a different concern from Staff Member #2 who also liked the feature but said, "the only risk is if they post something that's not approved." In retrospect in phase 3 Donor #2 appreciated this, saying "if it's been vetted by Milk Matters then one would trust it more." She also liked that this feature adds a layer of interaction with Milk Matters.

The two staff members were very excited about the suggestion to allow donors to declare when they have dropped off donations and have it reflected on the Milk Matters interface. In phase 1, Staff Member #2 excitedly stated "I definitely like the depot drop-off notification," and later in phase 2 said, "the depot part where I can see... (lists depot functionality) ... that would be my favorite." The new depot functionality was received well but raised some security concerns.

The Milk Matters' staff raised security concerns when the interviewer mentioned the depot locator, and the declare donation drop off functionality. Staff Member #1 explained in phase 1 that the depot locator "needed to be password protected because we didn't want someone suddenly having access to that... there was people who the depots were in their homes." In phase 2 the interviewer suggested having the user type in their donor number every time they want to access that feature, which Staff Member #2 responded with, "it would probably be safer that way." The other security concern was with people who are not registered donors dropping off breastmilk at depots and declaring those drop offs. In phase 2 both staff members asked, "is there a function for the donors to say they are stopping?" following the non-registered donor concerns, and explained that for every new baby the mothers donate with, they must do the screening again.

The findings of the last few questions in phase 1 of the interviews with Milk Matters relate to devices, privacy, costs and storage. Both staff members said "laptop if its possible would be easiest" when asked where they would prefer to use the application. Then when asked about privacy concerns, Staff Member #2 said the most important thing is "keeping donors' information confidential." In the interview with donors, all four participants said they were comfortable sharing personal information with Milk Matters. Staff Member #1 emphasized the need for a master password for the web application in phase 2 to enforce privacy and security.

The staff had to decide on a hosting platform, data to be stored, and budget for the system's operation. The interviewer explained the different options of hosting and what costs it would entail and the storage capacities of those options. Staff Member #1 was then happy to go with Firebase, as she said an upper range of R80 per month is reasonable and they would compromise the storage capacities to remain in the free tier - "we don't need long term storage", and she joked "we are always happy to pay less!" – but she still reiterated, "we can't have this as a long term solution if we can't afford it" and "either we need to pay for it or we need to persuade someone to pay for it, something needs to happen."

4.2 Non-Functional Requirements

4.2.1 Low Cost

As a result of the feedback from the Milk Matters staff, this was made a top priority requirement, and the system was designed to be as low cost as possible – possibly free.

4.2.2 Platform

To ensure the mobile application was usable by all of Milk Matters' donors, the mobile application had to be available for iOS and Android. The Milk Matters application was designed as a web application to be used on a laptop as requested.

4.2.3 Security and Privacy

Functionality relating to features Milk Matters was concerned about were created using co-design to ensure security and privacy.

4.2.4 Dynamic Content

The findings indicate that one of the biggest problems the 2016 application had was its static nature. The new system must provide dynamic content curated by Milk Matters.

4.2.5 Database Functionality

The mobile application must be dynamic, so a data storage that can be accessed by both front-end interfaces is needed.

4.3 Functional Requirements

4.3.1 Depot Locator

The depot locator was a valuable feature according to the findings. The depots needed a location, contact information, operating hours, and additional information associated with them. Milk Matters' requirement was that all this information is updatable, and that depots can be added, edited and deleted.

4.3.2 Education Articles

One of the features to be improved from the original app. Milk Matters wants to be able to upload, edit, and delete articles. Articles need to have a title, category, URL, date added, and additional information attached to it. Additionally, images would be nice to have in the article list.

4.3.3 News and Events

Milk Matters wanted to keep this feature as sometimes information and announcements are overlooked. Like articles, the news and events can be added, deleted and edited.

4.3.4 Donor Management

Feedback from Milk Matters relating to ensuring donors are registered led to the functionality of linking and removing donor numbers from user accounts.

4.3.5 Depot Donation Tracker

This is a proposed feature that Milk Matters became invested in according to the findings. The web application will be able to track an approximation of how much breastmilk is at a depot according to donors declaring donations.

4.3.6 Donor Article Suggestions

Donors liked the idea of being able to suggest articles as they felt it created more interaction with Milk Matters, and they would like to see the articles they suggest on the application.

4.3.7 Other

Some features were kept static in the mobile application and do not link to the web application, they are the following: The Frequently Asked Questions, Contact Milk Matters, Donation Tracking, Sharing Articles to social media, and Pre-screening Questionnaire.

5 SYSTEM DESIGN

The requirements discussed in the previous section were the features that were implemented into the final product of this project. This section will give an overview of the different features and screens in the Milk Matters web application.

5.1 Design Choices

Both applications were developed using the *Flutter*⁸ framework, which uses *Dart*⁹ as a programming language. One of the main requirements of the project was for the mobile application to be available for both *Android*¹⁰ and *iOS*¹¹. Flutter does this with a single code base [4]. This was ideal as the time set for the development of the final system was two weeks, and it allowed us to develop it in that time constraint. Flutter also allows for the development of Web Applications, so it could also be used for the Milk Matters web interface, and it allowed for code reusability from the mobile app and web application interchangeably [4]. Flutter's widgets and public libraries allow for faster User Interface design as it is often easy to find a layout widget online, which speeds up development, giving more time to focus on functionality.

There are two official development environments supported by Flutter, *Android Studio Integrated Development Environment*¹² was chosen due to it offering the best support for Flutter and Dart [4].

For the back-end *Firebase*¹³ was chosen mainly due to an attractive free-plan and inexpensive choice to expand. It is also easily integrated with Flutter as they are both provided by Google and libraries are available in Flutter to use Firebase services [4]. Firebase provides one real-time database and authorization services in their free plan, and due to the low storage needs of the Milk Matters' applications, this is perfect. It is also a NoSQL database, which allows for flexible data structures and that means it is more robust with the type of data that is stored [8]. This also means that it is easier to design the database for Milk Matters as individual depots, articles, and donors have a different amount of information from one to the other, which fits the NoSQL database structure [8].

⁸ <https://flutter.dev>

⁹ <https://dart.dev/>

¹⁰ <https://www.android.com/>

¹¹ <https://www.apple.com>

¹² <https://developer.android.com/studio>

¹³ <https://firebase.google.com>

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The system architecture is shown at a high-level view in Figure 17. It shows the client-server architecture [11] of the Milk Matters web application. The staff member accesses the web interface and the web interface communicates with Firebase for its authentication services. Then the staff member can use the web interface to upload, edit or delete content from the real-time database. Any changes made from the web application will reflect on the mobile application when the user uses it.

Figure 18 shows a package diagram of the Milk Matters web application. The client-server architecture can be seen here as well, and the Model-View-Presenter architecture [12] is also shown. The Dynamic Content package contains features that use the real-time database functionality through the Database Service provider. The screens cannot directly communicate with the database, they must use the provider. The screens use the provider to create objects using Model Classes. The Account Management package communicates with the authentication servers to provide authentication services to the web application, and it communicates with the Database Service provider to read and write authentication information from the database.

5.2 Design Functionality

The Milk Matters web interface was designed to be intuitive, easy to use, and assist Milk Matters' staff on everyday tasks. The color scheme is modelled after Milk Matters' branding, of different shades of pink, white, and grey. All the screens were designed to be very simple and easy to look at, without clustering, and material design principles were used [9] to ensure the design is relevant and recognizable.

5.2.1 Login and Home

The landing page when accessing the Milk Matters web application is the login screen, Figure 1, where the user is presented with a text input for their email, and their password, and a “Login” button, as well as some input validation using regular expressions as well as authorization features.

Once valid account credentials are entered, and the button clicked, the user is taken to the Home screen, Figure 2. This screen is the main navigation page which lets the user go to the other pages, the Dashboard, Depots, Education Articles, News and Events, and Account Management screens. A grid view was used, and each square has a title, description, and button to take the user to the relevant screen. A home or back button can be found on the top left in different screens for navigation. The title “Milk Matters” is also on the top-middle of each screen.

5.2.2 Dashboard

The dashboard screen, Figure 3, allows for an overview of depots and suggested articles in a list view. The user can look here instead of navigating to the relevant screens. If the user sees something in the dashboard that requires them to go see the specific item, they can press the button under the list view of the depots or suggested articles, and it will take them there. Things

like the amount of breastmilk currently stored in a depot can be seen here.

5.2.3 Depots

The Depot List screen, Figure 4, can be reached from the Home page or the Dashboard screen. Here all the current depots are displayed in a list view, with the depot name, address, contact number, additional information, and amount of breastmilk currently stored can be seen in each Depot Card. Each card also has a button bar, with a button to Process Collection of breastmilk which sets the count of breastmilk to zero and deletes the drop-off declaration entries from the database. The depots can easily be edited from this screen by pressing the Edit button next to the relevant depot. This will take the user to a new screen, Figure 15. Depots can also be deleted with the Delete button, which displays a confirmation pop-up like Figure 14. A new depot can be added by clicking the button with the plus icon on the bottom right of the screen, which will take the user to a screen that looks like Figure 16.

5.2.4 Education Articles

The Education Article screen can be accessed from the Home screen, and it looks like Figure 5. This screen has the same layout as the Depot List screen, with a list view of articles, with buttons allowing for editing and deleting. Editing an article will take the user to the Edit screen (Figure 6). Articles have a title, URL, date added, category, and description. Milk Matters enters this information when adding an article (bottom right button) or editing it. The date is automatically generated as the date when the article is added. The category is a drop-down list with 8 different categories. The delete button has the confirmation pop-up in Figure 14.

5.2.5 News and Events

This screen is the same as the Education Articles, the only difference is the information a news and events item has. In Figure 7, the add a new news and event item screen shows the input needed is the title, URL, description, with an optional image.

5.2.6 Donor Management

Clicking on the Go to Account Management button on the Home screen will take the user to the Account Management hub, Figure 8. Here the user can register a donor number, create a staff account, reset a staff password, and delete a donor number.

The Register button takes the user to Figure 9, where the user enters a donor number and email, presses the “+” icon, to register a donor in the system.

The Create Account button takes the user to Figure 10, where they input the new account's email, password, password confirmation, and the admin password for the web app. The account is created when the input is valid, and the button is pressed.

The Reset Password button goes to Figure 11, and after entering the email for the account of the forgotten password, and the admin password, and pressing the button, an email is sent to the email to reset the password.

Lastly the Delete a Donor Number, Figure 12, asks the user for a donor email for which the donor number must be deleted. Then when the button is pressed the user's account is no longer associated with a donor number which is used for security reasons in the mobile application.

5.2.7 Donor Article Suggestions

The Suggested Article Screen, Figure 13, can only be accessed by pressing the Go to Suggested Articles button in the Dashboard screen, Figure 3. Then a list view of suggested articles is displayed, with Suggested Article Cards. Each card has a title, URL, date suggested, description, donor name and number. The user can press the Accept button and they will be taken to the Education Article Edit screen, Figure 6. The user can also press Decline, and the deletion confirmation dialog will pop-up, Figure 14. Deleting will delete the suggestion from the list and database.

6 FINDINGS

The three phases of this project and the online nature of the process resulted in interesting findings. The participants gave valuable feedback on the design process, on the system, and interesting observations through the project.

6.1 Design Process

"It is not letting me turn on the video... it is not letting me use the video," technical difficulties like the one in the first interview with Staff Member #1 was a recurring theme in the online interview process. Phase 2 saw similar difficulties with Staff Member #1 and #2, but with microphone issues. At the end of the phase 2 interview Staff Member #2 told me, "sorry for the technical difficulties with me every time" as phase 1 also saw technical difficulties with her. In the phase 3 interview with Staff Member #1, the interviewer's screen froze as I was screen sharing the web application. The other form of interruption was the participant having to tend to their babies, this happened in four out of the twelve interviews with donors.

At the end of phase 2 and 3 interviews, the participants were asked for their thoughts on the process of online interviews and evaluation to which the answers were mostly positive. Donor #1 responded "you guys were very professional, I felt comfortable." Similarly, Donor #4 responded with "I mean, how many guys at university are dealing with breastfeeding. You guys have been very mature... You have made me feel comfortable, I have nothing negative to say." Donor #2 and #3 enjoyed the process but mentioned "that was a bit weird," referring to the evaluations. Staff Member #1 was pleased with the online format as she "could do it while at work and didn't have to go anywhere so we both found that it worked really well for us." She found it convenient.

The online nature of the evaluations had the interviewer sharing their screen and controlling the artefact according to the participants verbal diction. There was mixed feedback on this. Donor #2 commented, "It was a bit strange, I would've immediately touched buttons, but I had to tell you and wait. That was a bit weird." Donor #3 called it weird, and Donor #4 mentioned "It was just a bit slow", and she also joked during phase 2 that "I feel like you guys are testing me, and I have no idea what to do." Staff Member #1 on the other hand, thought "it worked really well, made it very clear to go step by step on the screen, it made it very accessible."

The findings around the perceived difficulty of the evaluations related to previous exposure to the prototype, and technical difficulties. Most of the participants agreed with Staff Member #1 saying "Once you've done it once you know," referring to knowing how to navigate phase 3 due to the evaluation in phase 2. Donor #2 said that "I found this time easier due to the previous evaluation." The opposite side of the perceived difficulty is the participants blaming errors during the evaluation on the online nature of the interview. Donor #3 "Thinks text was small, but would be better on actual phone." Staff Member #2 said something similar in phase 3, she did not see a button at first, but said "I don't think it's a design problem, it might be because its on your screen."

6.2 System Feedback

The findings for the web application's design are positive from both participants. After phase 3's evaluation, Staff Member #1 praised the web application "It is just so easy to use I can see what to do... it is just so user friendly I think it will be very useful." Staff Member #2 commented that "it makes me want to donate" when she finished the evaluation for phase 3. The staff "thought it was quite intuitive," but Staff Member #2 also commented that a "once off training was needed." Staff Member #1 mentioned that a small user instruction manual would suffice.

The feedback from donors and staff members indicates that the favorite functionality is declaring a donation drop-off. Donor #1 comments on the feature, "Yes, at least Milk Matters knows the milk is there," and that "it would help you feel more involved." Donor #2 was also excited, as "Milk Matters didn't know in real-time when milk was dropped off" but the feature would improve that. Staff Member #1 liked the feature as it would help save time with collections and "it could give the mom satisfaction to tell us I just dropped off... I think it would be rewarding for the moms." Donors also mentioned donation tracking as a favorite, Donor #1 elaborated on this, "It's nice to know you've donated so much milk and fed so many babies, it makes it more real."

Milk Matters responded with excitement to the artefact evaluated in phase 3 and exclaimed "You have exceeded our expectations!" Staff Member #1 called back to the 2016 project, declaring that this project has "taken what Chelsea started and took it to a new level." Staff Member #2 says that she is "very excited to use it. It is more than she expected" and that she now expects to get "better

depot management” from the web application. Both staff members showed gratitude when giving feedback on the web application.

6.3 Other Findings

The findings for phase 1 of the project mention the sensitive demographic, language use, and considerations needed in order to work in this environment. When suggesting features in phase 1, such as the visualization of how many babies have been fed with the donation tracking, Staff Member #1 emphasized “think carefully how it is worded and how it is shown.” She also says to the team, “be careful how we word things and what we say, it’s a sensitive issue.” Lastly, she mentioned the importance of “...how we set it up on the app to give that feedback to the mom because I do think that feedback is very rewarding.” In phase 3, Staff Member #1 reflected on the concerns she had starting out the project – “All my concerns you took note of, we worked through everything... all the things I was worried about were addressed I am happy.”

The phase 1 interviews brought up functionality that the donors who co-designed the 2016 application had suggested then. This is a donor-to-donor communication platform. Three of the donors said they would like to have a platform to “get real information from people who have been there” – Donor #4. Donor #1 mentioned that “sometimes with the breastfeeding it’s nice to speak to someone that’s in the same position, it sometimes helps. Having a face doing something that you’re doing, it might encourage more people to donate.” Donor #2 suggested “a daily tally, some sort of data so you feel like you are a part of...”

When these features were suggested to Milk Matters’ staff, they explained it is not feasible in their context. Staff Member #1 had a few statements when it came to this topic. “moms are very sensitive about how much milk they have and we just don’t want to be making anybody feel bad.” Regarding sharing donation amounts on social media, as well as “where we are almost pushing the sharing it almost feels like its setting up more of a competitive thing.” Lastly, she says “things like that which can seem pretty small but they become quite tricky because moms don’t always understand about the code and think we are being ridiculous, but we are not able to have a conversation with them.” This was in response to donor to donor communication.

In discourse with Milk Matters during phase 2 interviews, Staff Member #1 asked the interviewer “is this something you are looking at other milk banks.... If it works how we hope it is going to work and we love it, is this something that could be rolled out?” With the intention to share this system to other human milk banks. She playfully exclaims “look at what we’ve got, do you want this too?! It is now available!” referring to the web application. In phase 3 the interviews tried to dig deeper into this, and the responses were, “as a communication tool from the public to the organization I imagine it can be adapted to be quite versatile” – Staff Member #1. Staff Member #2 claimed that “other non-profit, donation based, off-site depot organizations could use this system.”

7 DISCUSSION AND ANALYSIS

Interesting themes can be identified within the findings of this project, themes relating to designing alongside an NPO, conducting a typical field work project completely online, and the transition of a static application to a dynamic one.

7.1 Conflicting Stakeholder Requirements

From Wardle et al. [20] research, and our own findings, it was obvious donor mothers wanted some form of interaction platform for donors. This feature can be justified by Dizon’s research, which discusses mothers feeling lonely and alienated if they do not have others who they can empathize with [3], which is what the findings highlighted as one of the donors mentioned they would like to interact with mothers in the same position as them as they have been there before.

Another feature that was at first thought to be valuable to create more motivation for donors and exposure for Milk Matters as an organization, was sharing breastmilk donation amounts on social media. Sharing donations could act like the motivation and trigger in the FBM, but if the donors who see it do not have the ability to donate any more, this will have negative effects [5]. The social media post can also act like a PSA, using social dynamic cues to influence others to donate more [6], but the use of such persuasion is unethical in a breastmilk context.

There was a demand for the features and literature also promised benefits from such techniques, so why were these features not implemented? Milk Matters as an organization has the responsibility to ensure their donors have trustworthy information which does not violate breastmilk donation regulations. As in the findings, Staff Member #1 explained why these features are unfeasible. There are risks involved in creating competition in the breastfeeding donation environment, as well as the problems that can arise from distributing misinformation. Donors can feel lesser as breastmilk production is a sensitive topic, or they can neglect their child of breastmilk to donate extra [13]. Misinforming donors is a problem because there are certain conditions required for breastmilk donation, and things such as suggested medication can render breastmilk unusable [13].

Using a UCD approach with Milk Matters to ensure that their concerns were addressed was key as pointed out by the research done by Melissa Ho [7]. The system created from this project had the potential to be harmful if we tried to comply with all the requirements of the primary users (the donors). It was important to balance the requirements between the two stakeholders of the project, and ensure they were satisfied even if not all their requirements were met [1], as feedback from both of them was crucial for a functional system to be created [7].

7.2 Online Field Work

The process of performing online field work came with many benefits, especially in the context of mothers with small babies. I had anticipated interruptions by babies through the interviews, but as the findings highlighted, only a third of the interviews with

donors were interrupted, and often only briefly. Balaam et al, and Wardle et al. [1, 20] performed co-design projects with breastfeeding mothers with main themes of interrupted interactions and single-handed interactions. This was not reflected in this project, and it is most likely due to the benefits of online field work. Interviews can be done from any location, and at flexible times, so mothers could do interviews at home while their babies were sleeping. The other benefit for participants is they did not have to expose their babies to strangers.

The findings also showed the downsides of performing online field work. Technological issues caused delays, and affected some of the recorded interviews, due to recordings cutting out or bad microphones. These were minor hindrances as the project continued successfully even when technical interruptions occurred.

The main downside of performing this research online, was the way the evaluations took form. Due to the online nature of the work, paper prototypes were not feasible and instead, participants were provided with more sophisticated, interactive prototypes. This could have impacted feedback, as people tend to withhold criticism when an artefact looks more sophisticated [21]. The evaluations were controlled by the interviewer, and the participants had to dictate their actions to perform them. As the findings showed, this created weird, awkward situations when performing evaluations, and could have discouraged participants. The participants also had no way to organically navigate the applications, which does not give accurate feedback on the usability of the application. The sophisticated nature of the prototype could have positively skewed the performance when it came to the phase 3 evaluations as many participants felt they received training from phase 2.

The findings presented a trend of participants justifying mistakes made during the evaluation on the technical affordances of the interviews. The feedback they gave with regards to intuitive design usability was sometimes conflicting with the usability evaluations, as they would praise the usability, but when they were performing tasks, they had difficulties [2]. This made it difficult to distinguish which features were not intuitive, and which ones were due to technical issues. This can be explained by Nicola Dell's research. The participants were biased towards the application as they knew that the interviewer was also the developer [2]. The bias is made worse when the interviewer is controlling the artefact they developed with feedback from the participants.

7.3 Affordances from System

The findings show that the improvement of the application from static to dynamic allows Milk Matters to increase donor engagement and affirming feedback without direct communication. According to Dizon [3], mothers want to feel like they belong to a community, and donors reported that they feel like they are a part of something bigger when they can easily engage with Milk Matters, such as declaring donations, suggesting articles, and sharing Milk Matters' content.

The system has created a feedback loop between donors and Milk Matters, with the allowance of declaring donation drop-offs. This feedback loop gives Milk Matters information that is crucial and that they would not have been able to easily access [10]. Donors notified drop offs via email, but now they have a centralized system which will give Milk Matters a more holistic picture of donations, instead of individual emails [10]. The donors explained that declaring a donation from the mobile application makes them feel like they are making a difference, and they do not feel isolated as donors as it gives them visibility. Knowing Milk Matters would be able to see that donation motivated donors.

The donation drop-offs and donation tracking are in-line with the donors' altruistic motivations to donate. With the tracking functionality they can see how many 50ml feeds they have donated, as well as cumulative amounts of donations. When they declare a drop-off of those donations, it gives a more direct feeling of helping, as now they know that Milk Matters is aware their donation is at the depot for when it is needed. This is in line with the initial requirement of increasing donor engagement.

Milk Matters brought up distributing this system to other human milk banks, and later on expanded the idea to other non-profit, donation based, off-site depot organizations. Excluding research, the system was developed within two weeks, with an extra week for refining it, by three Honors Computer Science students. The only costs now are the App Store and Google Play Store deployment costs, which will be covered by the University of Cape Town's accounts. With extra work and research put into this, a general framework could be developed to fit basic criteria for other NGOs. This shows that it would be possible to expand the system to further organizations, and the possibility of designing such a system in a limited environment.

8 CONCLUSIONS AND FUTURE WORK

This project aimed to create a system that will improve the donation experience for Milk Matters donors. Through the use of a UCD approach, and an online development process with Milk Matters staff and donor mothers, a system consisting of a donor mobile application, a Milk Matters web application, and a back-end providing support to these, was created. The system was well received by the participants and the feedback given indicates that the project was a success. However, this can only be said with confidence after the system is deployed and has been used for some time, as that is the only way to measure the donors' improved experience due to using the application.

The secondary aim of the project evolved from a non-functional requirement from Milk Matters of the system being as low cost as possible. This aim, to keep costs minimal was achieved as the only costs for the system currently will be deployment costs. The cost of the system can increase in the future, but the system was designed using tools which would have a low-cost scalability if ever needed. This aim also led to making this project open source,

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as it has the potential to evolve into something that can be adopted in other similar contexts for NGOs. It also highlights the possibility of creating a system with low resources, a small team, and a short time frame. This could be a valuable contribution to Software Engineering and HCI fields.

Future work can involve improving the application to fit more of the organization's and donors' needs. The system currently relies on donors using it for a lot of the functionality to be useful, if this could be improved by having a compensation measure from Milk Matters side for donors not using the application it would add value to the system. Lastly, this project can be taken further to explore online research methods in a pandemic, as well as generalizing a development method for other NGOs, where cost can be as low as possible.

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Appendix:

Dart Documentation for Milk Matters Web Application:

https://gerhardserton.github.io/Milk_Matters_Staff_Facing_App_Documentation/

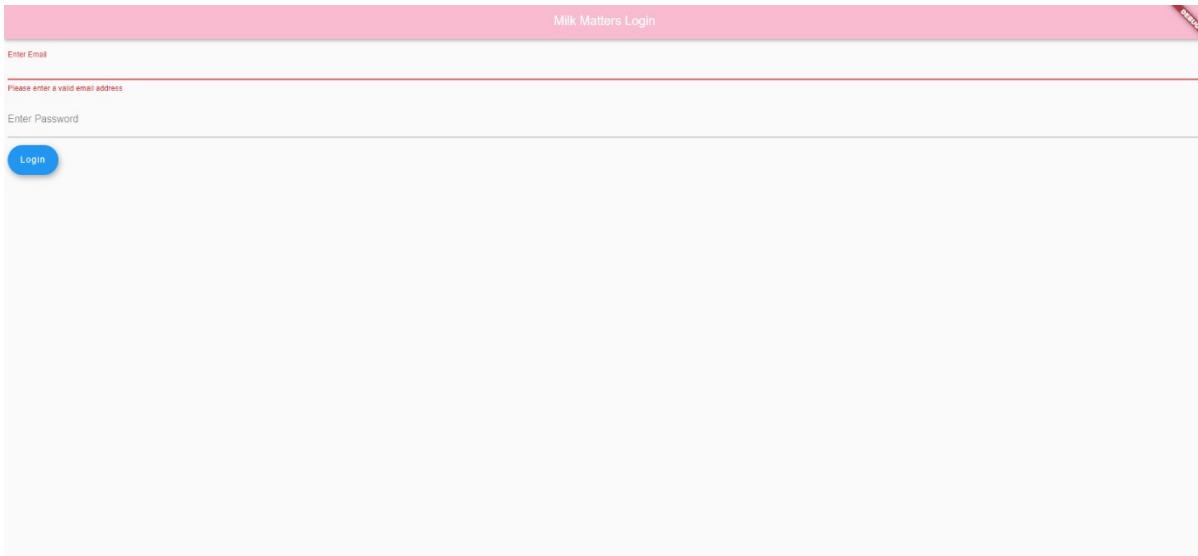


Figure 1: Login screen

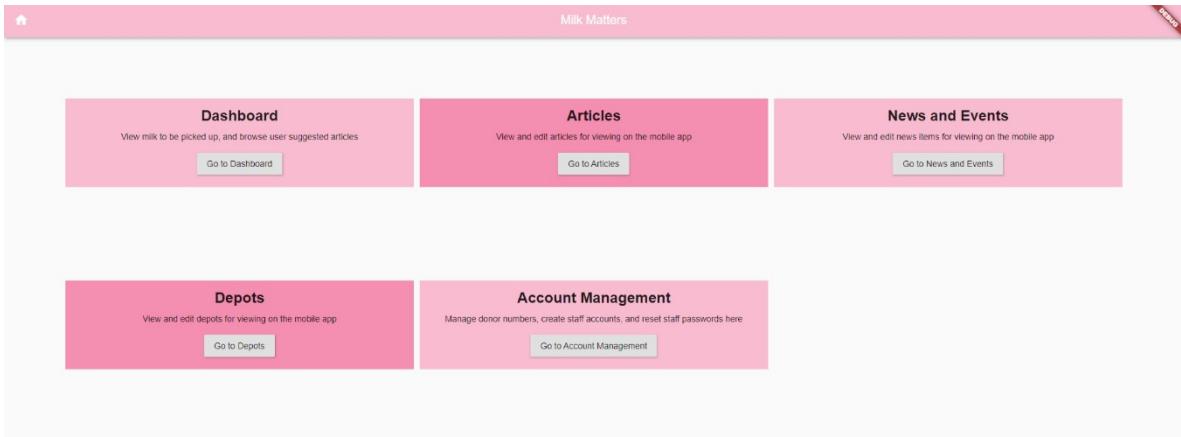


Figure 2: Home screen

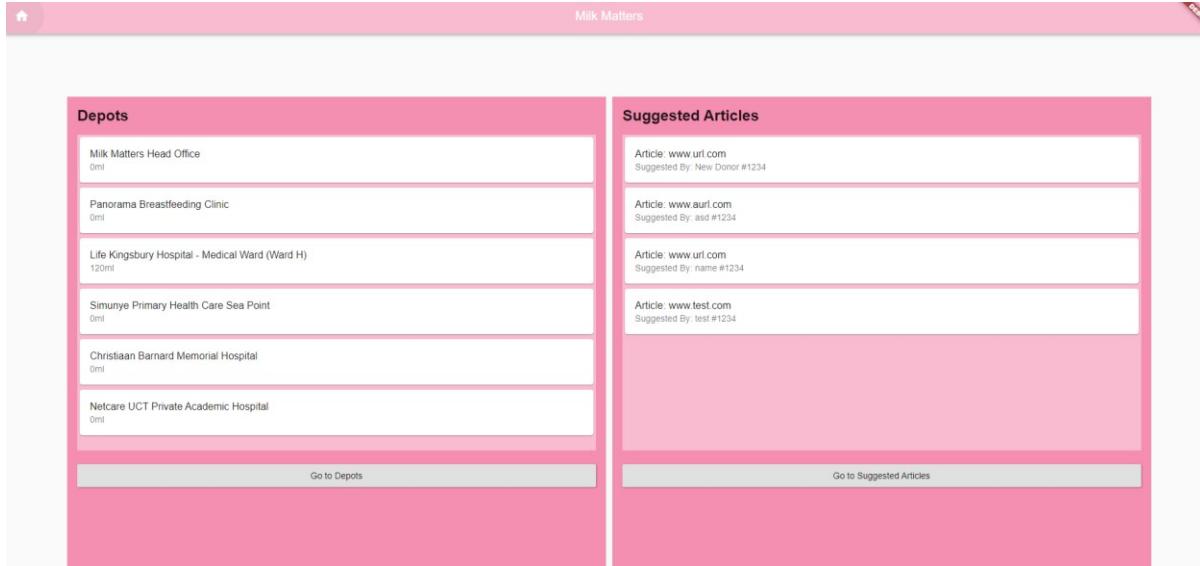


Figure 3: Dashboard screen

Figure 4: Depot List screen

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The screenshot shows a list of four education articles under the 'Milk Matters' header. Each article card includes a title, URL, date added, category, a description input field, and 'Edit' and 'Delete' buttons.

- Article 1: Breastfeeding new title
www.BREASTMILKISOBVIOUSLYGOOD.org
Date Added: 15/9/2020
Category: Breast Conditions & Common Concerns
- Article 2: Breastfeeding Basics
http://milkmatters.org/breastfeeding-breastmilk/
Date Added: 15/9/2020
Category: Breast Conditions & Common Concerns
- Article 3: Breastfeeding technologies coming in 2020
www.breastfeed.com
Date Added: 15/9/2020
Category: Breastfeeding
- Article 4: Breastfeeding and the working mom
http://milkmatters.org/breastfeeding-breastmilk/the-working-mother/

Figure 5: Education Article List screen

This is a form-based screen for adding a new education article. It features fields for 'Enter Article title' (with validation 'Please enter a title'), 'Enter Article URL' (with validation 'Please enter a valid url'), 'Enter Article Description' (with validation 'Please enter a description'), and a 'Select Image' button. A note indicates 'No Image Selected...' and a blue '+' button is available for adding more images.

Figure 6: Add new education article screen

This screen is similar to Figure 6 but is intended for news and events. It has identical fields for 'Enter title', 'Enter Article URL', 'Enter description', and an 'Select Image' button. It also includes the note 'No Image Selected...' and a blue '+' button.

Figure 7: Add new News and Events screen

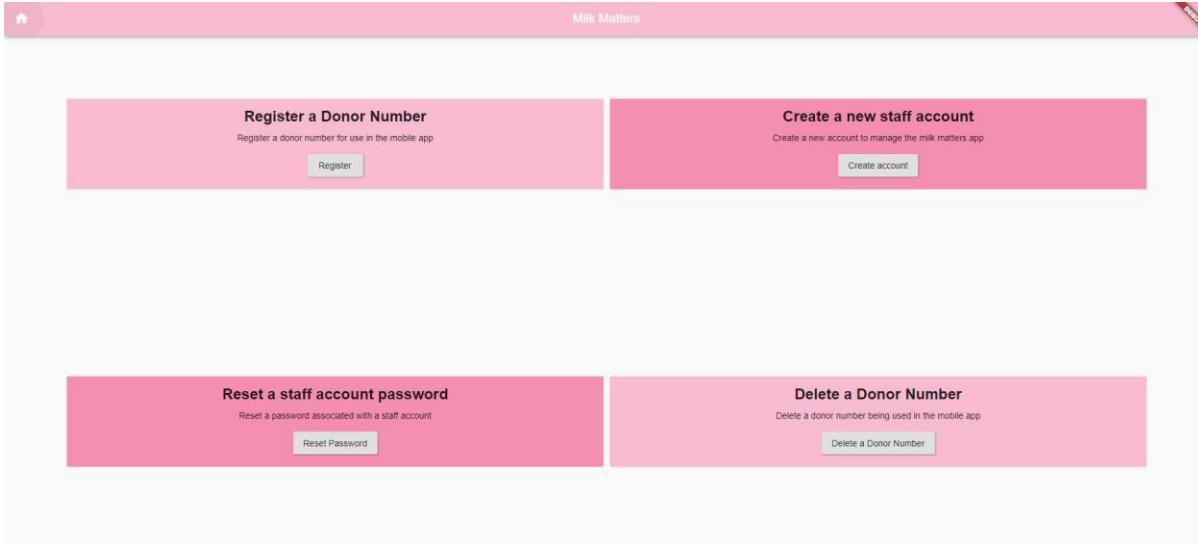


Figure 8: Donor Management grid view screen



Figure 9: Register donor number screen



Figure 10: Create Staff Account screen

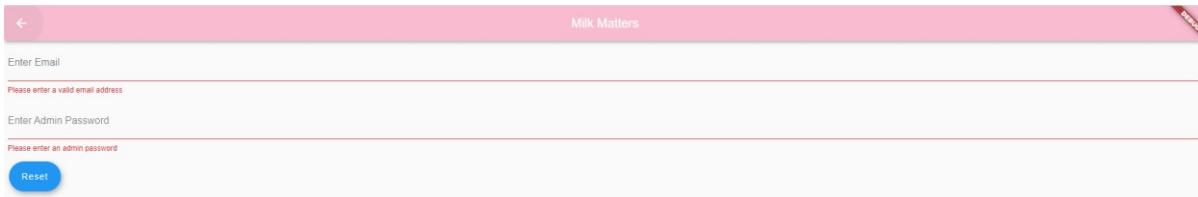
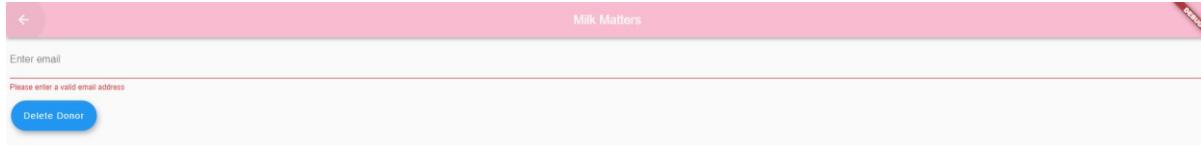


Figure 11: Reset Staff Password screen

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The screenshot shows a mobile application interface titled "Milk Matters". At the top, there is a pink header bar with a back arrow icon, the title "Milk Matters", and a red "Logout" button. Below the header, there is a form field labeled "Enter email" with a placeholder "Please enter a valid email address". A blue button labeled "Delete Donor" is located at the bottom of the form.

Figure 12: Delete Donor Number screen



The screenshot shows a mobile application interface titled "Milk Matters". At the top, there is a pink header bar with a home icon, the title "Milk Matters", and a red "Logout" button. Below the header, there is a table listing four suggested articles. Each row contains a small icon, the URL, the title, the date suggested, and a description, followed by two buttons: "Accept" and "Decline".

✳	www.url.com	New Donor	Date Suggested: 9/9/2020	Description: Some comments	Accept	Decline
✳	www.url.com	asd	Date Suggested: 9/10/2020	Description: some comments	Accept	Decline
✳	www.url.com	name	Date Suggested: 9/14/2020	Description: some comments	Accept	Decline
✳	www.test.com	test	Date Suggested: 9/18/2020	Description: some comments	Accept	Decline

Figure 13: Suggested Articles screen



Figure 14: Confirm Dialog pop-up

Milk Matters

Enter Depot Name
Milk Matters Head Office

Enter Address *Note this must be exactly as google lists it*
Mowbray Maternity Hospital, 12 Hornsey Road, Mowbray, Cape Town, 7700

Enter Contact Number
083 548 7574

Enter Comments
Closed after 5pm

+

Figure 15: Edit Depot screen

Milk Matters

Enter Depot Name

Enter Address *Note this must be exactly as google lists it*

Enter Contact Number

Enter Comments

+

Figure 16: New Depot screen

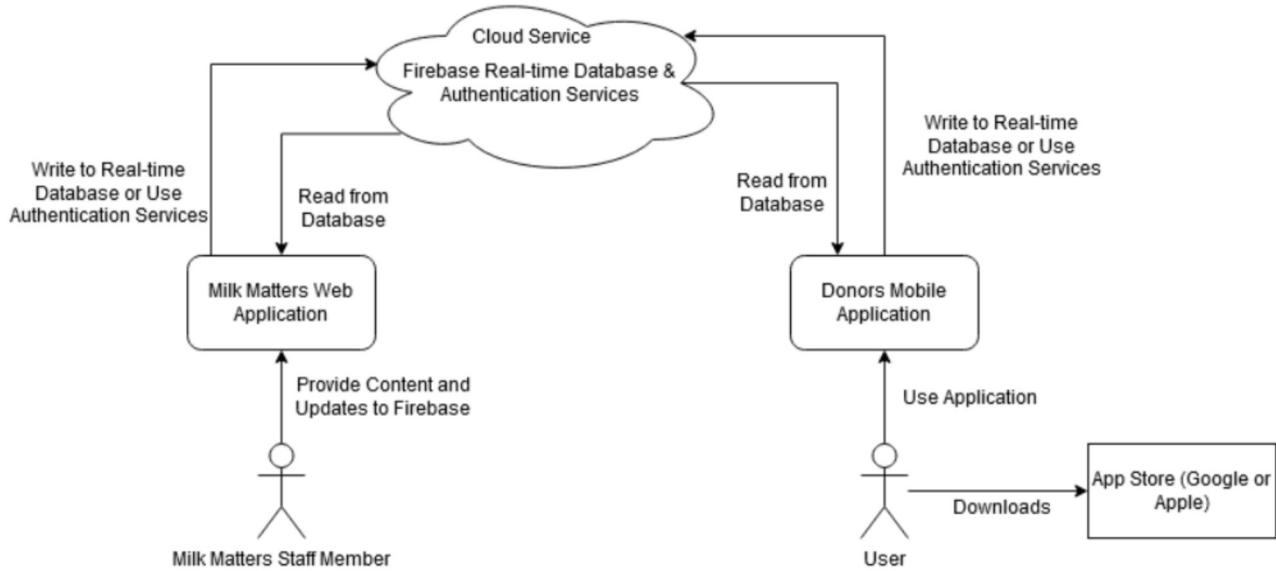


Figure 17: System Diagram

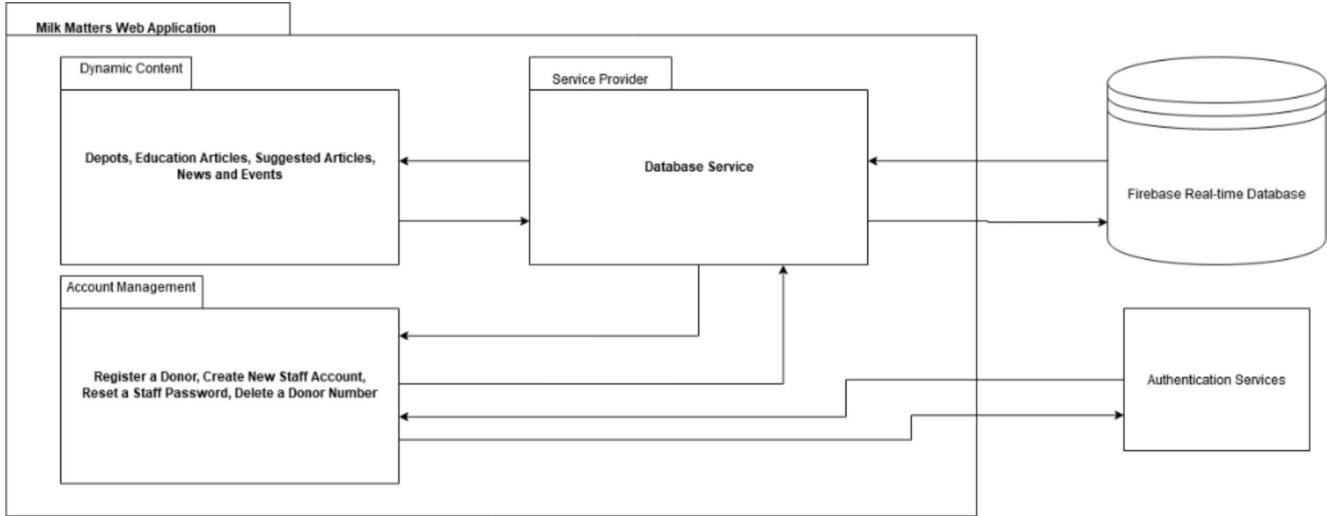


Figure 18: Package Diagram

Which of these tools would you find useful in a potential Milk Matters App?

7 responses

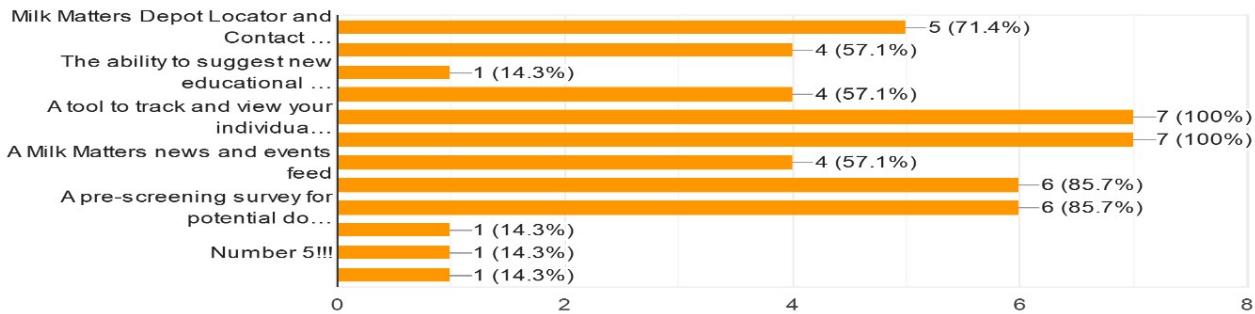


Figure 19: Survey Question 17