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Category	Min	Max	Chosen
Requirement Analysis and Design	0	20	17
Theoretical Analysis	0	25	0
Experiment Design and Execution	0	20	0
System Development and Implementation	0	15	15
Results, Findings and Conclusion	10	20	15
Aim Formulation and Background Work	10	15	13
Quality of Paper Writing and Presentation	10		10
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Milk Matters: Milk Donor Motivation

[Using Mobile Technology to Motivate Breast Milk Donation]

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ABSTRACT

The aim of this software engineering project is to develop a mobile application for Milk Matters, a non-profit human milk bank. The primary purpose of the mobile application is to motivate mothers to donate their excess breast milk to Milk Matters, and improve mothers' experiences as donors and their interaction with Milk Matters. This paper describes the design and development of the Milk Matters mobile application, which involved an iterative co-design process with both Milk Matters, our client, and their donor mothers, the end-users of the application. This work also places emphasis on human computer interaction, and our experiences of working with mothers of young children as end-users. We deemed the Milk Matters mobile application to be a success due to the positive feedback it was met with from both our client and end-users, and the fact that it satisfied their most important needs and requirements. Furthermore, based on the responses of the mothers who participated in our study, it appears that the mobile application would likely achieve its ultimate aim of motivating mothers to donate their excess breast milk, and thereby increasing the supply of breast milk, to a human milk bank. However, due to time constraints and the inherent variability of the supply of breast milk, we were not able to support this hypothesis empirically. As such, this remains as future work.

Keywords

Milk Matters; Co-Design; HCI; Milk Donor Motivation, Mobile Application; Android; Human Milk Bank

1. INTRODUCTION

The aim of this software engineering project is to develop a mobile application for Milk Matters¹, a non-profit human milk bank. Milk Matters' core activities include sourcing human breast milk from donor mothers, and distributing the donated breast milk to the neediest of infants in a safe and effective manner [9]. This project focuses on the sourcing of both donor mothers and their excess breast milk. As such, the primary purpose of the mobile application is to motivate mothers to donate their excess breast milk to Milk Matters, and improve mothers' experiences as donors and interaction with Milk Matters. The mobile application endeavours to achieve its purpose by providing mothers with a convenient and central means of: tracking and visualising their donations, receiving feedback from and interacting with Milk

Matters, streamlining the donation process, and educating themselves about relevant topics. Despite the bulk of the functionality being designed to motivate existing donors to donate more, and for longer, the application also places an emphasis on encouraging mothers to become donors.

Since this project has a significant focus on human computer interaction (HCI), we followed a co-design process with both Milk Matters and their donor mothers. The co-design process was initiated with a requirements and needs analysis session with Milk Matters. Following this initial meeting, we held a brainstorming and prototyping workshop with donor mothers, which comprised the first of the project's three design iterations. Each design iteration consisted of a *design, prototype, and evaluation* phase. The prototype produced by each iteration was of a higher fidelity than the last, beginning with a simple paper prototype, and ending with a fully functional application. In order to facilitate this iterative design cycle, and accommodate the short time frame of the project and changing requirements, we used an agile software development methodology. This agile methodology was paired with pair programming practices in the early stages of the project, in order to establish a strong base for the components of the application which were coded individually later, and ensure consistency throughout all aspects of the software product.

Evaluation of the prototypes needed to accommodate the time and resource constraints on new mothers. As such, the primary mode of feedback was through online surveys. Workshops, interviews, and cognitive walk-throughs with small groups of mothers were also instrumental in designing an application that most effectively satisfies mothers' needs and wants. This paper discusses the process of designing and developing the Milk Matters application, and places emphasis on HCI and the co-design process. This paper also focuses on the extent to which the mobile application is able to motivate mothers to donate their excess breast milk to a human milk bank, and improve their experiences as donors and interaction with Milk Matters.

2. BACKGROUND

2.1 Project Significance

Human breast milk has vital nutritional and immunological properties that cannot be replicated in formula [12]. As such, the use of human breast milk in an infant's diet results in positive health outcomes [12, 11]. This is especially true for fragile infants [13], such as sick or premature infants in Neonatal Intensive Care Units (NICUs), whose immune sys-

¹www.milkmatters.org

tems may be weak. In addition, formula or alternate forms of food may result in health complications for some infants, such as those whose bodies are intolerant to it [12]. For these and other reasons, human milk is considered to be a vital medical resource and the ideal source of food for infants, as stipulated by the World Health Organisation [12, 10].

Mothers who are unable to provide their children with mother's own milk may be eligible to receive breast milk from a human milk bank [8, 12]. Unfortunately, the demand for human breast milk, and in particular breast milk from human milk banks, often exceeds supply [10, 4]. As a result, breast milk donated to human milk banks is usually only available via prescription by a health professional, and reserved for infants with a medical need [4, 12]. By providing mothers with a mobile application which motivates them to donate their excess breast milk, we could increase the supply of breast milk to human milk banks. As a result, more needy infants would obtain access to human breast milk, which would promote positive health outcomes for those infants, and potentially even save lives. A secondary benefit of the mobile application is the educational content it provides to mothers, regardless of whether they are donors or not. This educational content may enable and encourage mothers to increase their own breast milk supply, in order to provide for their own children, thereby potentially decreasing the overall demand for donated human milk. An intended byproduct of providing useful content to non-donor mothers is converting them into donor mothers, primarily by making it quick and easy to become a donor. This would, in turn, also increase the supply of breast milk to human milk banks.

2.2 Milk Matters

Milk Matters is a non-profit human milk bank that operates in the Western Cape, in South Africa. Milk Matters' primary activities include sourcing human breast milk from donor mothers, pasteurising the milk for safe consumption, and distributing the breast milk to appropriate recipients. Due to the high demand for donated breast milk, and the medical importance thereof, Milk Matters typically only distributes donated breast milk to the neediest of infants, such as sick or preterm infants in NICUs. Most of Milk Matters' present interaction with donor mothers takes the form of emails, both automated and personal. This makes sourcing and attaining donor mothers and their excess breast milk a labour intensive task, especially for a small non-governmental organisation like Milk Matters.

2.3 Breast Milk Donation

In order to become a donor, a mother has to undergo a rigorous screening process which includes, amongst other things, HIV and blood tests. The mother is also required to make a large initial deposit of breast milk, partially to justify the milk bank's expense of screening that mother. Should the mother pass the screening process, there are also restrictions imposed upon her diet, in order to ensure the safety and quality of her breast milk. Once the mother is a registered donor, she has to collect jars to store the milk she expresses for donation from one of Milk Matters' depots. Once she has taken the time and energy to express milk for donation, she then also has to drop the milk off at a depot.

Evidently, this is a demanding process that may deter many mothers from donating [11, 4], especially considering the existing constraints on mothers' resources. There are

also other factors which discourage mothers from donating their excess breast milk to a human milk bank (see section 3. Related Work). Consequently, many mothers opt to dispose of their excess breast milk, or engage in milk sharing, which is the practice of sharing human breast milk directly with a recipient mother² [10, 12]. This often results in wastage, or human milk being distributed to less needy infants than those typically served by human milk banks. Furthermore, there are many concerns about the quality and safety of breast milk involved in milk sharing arrangements [1, 2, 4], partly due to a lack of donor screening, pasteurisation, and/or other safe practices. In order to overcome the difficulties and issues associated with donating breast milk to a human milk bank, it is clear that mothers need significant motivation to donate, be it altruistic or otherwise. This project aims to provide mothers with the necessary motivation, and make the donation process more convenient, simple, and engaging.

3. RELATED WORK

Despite numerous mobile applications centred around breastfeeding being available to mothers, we are unaware of the existence of any research directly into the use of mobile technology to promote human breast milk donation. However, there is significant research into what motivates mothers to donate their breast milk and, in particular, mothers' experiences with, and perceptions of, donating their excess breast milk to a human milk bank. This research is directly relevant to our project; given our aim of motivating breast milk donation, it is critical that we understand what exactly drives mothers to donate, and what deters them from donating to human milk banks.

3.1 Motivation to Donate Breast Milk

The motivation to donate breast milk is mostly the same for mothers partaking in milk sharing and mothers donating to a human milk bank [5]. Many donors are motivated by an altruistic desire to help somebody [11, 5]. Others feel that they have a social responsibility to donate excess breast milk. The knowledge of a particular infant's need for human breast milk is also a significant motivating factor, as is the case in a large number of milk sharing interactions. In the case of donations to human milk banks, donor mothers are frequently motivated merely by their knowledge of the human milk bank, and the need they have for human breast milk. Other mothers are motivated by the hope that somebody else would do the same for them if their own children were in need of human breast milk [5]. Generally speaking, mothers consider their breast milk to be a valuable resource, as they are aware of its nutritional properties and ability to sustain life. Furthermore, mothers who express milk for their own (or other peoples') children invest significant time and energy into doing so, which adds to the perceived value of their milk [11]. As such, many mothers who have an excess supply of breast milk thus do not want to waste what they consider to be a precious resource [11, 5]. Lastly, the role of health professionals in convincing mothers to donate breast milk has been described as vital [5].

However, many mothers are reluctant to donate to human milk banks in particular, as opposed to partaking in some

²Examples include wet-nursing and peer-to-peer milk sharing.

form of milk sharing arrangement. As described by Perrin et al, some mothers seeking to donate their breast milk expressed concern that the milk donated to human milk banks is not, in turn, free for recipients[11, 4]. Another major deterrent for mothers considering donating to human milk banks is that, in many cases, donors do not know which recipients will benefit from their breast milk [4]. Since many mothers consider their breast milk to be a valuable resource [5, 11] they would like to know that it benefits a sufficiently needy and deserving recipient [4]. Milk sharing is thus often a more appealing prospect, as the donor is able to choose who benefits from her breast milk, and witness the specific impact her contribution is having [5, 4].

3.2 Blood Donation Mobile Applications

As mentioned, there appears to be little in the literature pertaining to the use of mobile technology to motivate and facilitate the donation of breast milk to human milk banks. However, there is research into the use of mobile applications to facilitate and promote blood donation [7, 3, 6, 15, 17]. The similarities between human milk donation and blood donation [16] render this research relevant. The literature contains little about the success and effectiveness of these blood donation mobile applications, in terms of their ability to motivate donation. However, research conducted by Yuan et al found that the majority of blood donors that partook in their study were ready for, and would make use of, a blood donation mobile application [17]. It can be assumed that the same would be true for milk donors and a milk donation mobile application. As such, there appears to be potential for mobile technology to influence mothers' behaviour and motivate human breast milk donation.

4. APPROACH

4.1 Software Engineering

4.1.1 Stakeholders

The primary stakeholder in this project is our client, Milk Matters. The mobile application had to be aligned with their needs, and fit the constraints imposed by their organisation. Another major stakeholder in the Milk Matters mobile application is the actual end-users: both current and potential donor mothers. An indirect, but equally important, stakeholder is the recipient mothers and their children who would benefit from the donated breast milk. Lastly, the University of Cape Town, and in particular its Department of Computer Science, is a stakeholder in this project, due to the outcomes being a reflection on it. It was decided that the mobile application itself would be co-owned by Milk Matters and the University of Cape Town, given their roles in its co-design and development. The content provided by the mobile application is the property of Milk Matters and, in the case of the educational resources, the third parties from which it was sourced. This paper is the property of the University of Cape Town. On conclusion of this project, the Milk Matters mobile application will be freely available for download on the Google Play Store ³.

4.1.2 Team

³<https://play.google.com>

The software development team consisted of two of the University of Cape Town's Computer Science honours students, namely Chelsea-Joy Wardle and Mitchell Green. The focus of Chelsea-Joy's work is the educational component of the application, whereas this paper focuses on the donation tracking and visualisation component. Both students designed and developed the core of the application, as well as other supporting features and functionality. As such, both papers discuss the design, development, and evaluation of these other features and functionality.

4.2 Platform and Architecture

The Milk Matters mobile application was designed to run natively on the Android platform. We decided to develop for Android devices, as opposed to iOS or Windows Mobile devices, for a variety of reasons. Firstly, the relative affordability of Android devices ensures that both the rich and poor would have access to the mobile application. In addition, since Android devices hold the majority share of the global smartphone market ⁴ [14], the mobile application should statistically be accessible to the majority of potential users. Secondly, the openness of the Android platform makes it ideal for the inexpensive development of a mobile application. We opted to support Android APIs 15 and onward, as this ensures that the mobile application is accessible to 97.4% of the devices on the Google Play Store⁵. Our decision to not support platforms older than API 15 arises from the fact that doing so would preclude the application from using certain modern Android components and libraries. Our application makes use of the *Model, View, Controller* architecture. All data is stored in a SQLite database, all controller and model code is written in Java, and Android's standard backwards-compatible components are used for the view.

4.3 Software Development and Testing

4.3.1 Software Development Methodology

In order to facilitate and support the iterative co-design process, we opted for an agile software development methodology. We chose an agile development methodology in order to accommodate for the changing requirements imposed by an iterative co-design process, as well as the short time we had to develop a relatively large number of features. We made use of pair programming to develop the core, or skeleton, of the application, as well as the features and functionality common to both projects. The purpose of using pair programming was to ensure stylistic and technical consistency, both in terms of the user experience and code itself. Each item of functionality marked for implementation was completed in a short sprint, and no other functionality was worked on until that sprint was finished. By doing this, we ensured that each increment of the application resulted in a fully functioning software product.

4.3.2 Development Environment and Tools

We used the recommended Android development environment, namely the Android Studio Integrated Development Environment⁶, to create the Milk Matters mobile application. Similarly, we used the standard Android SDK and

⁴80.7% of the worldwide smartphone operating system market as of quarter 4 in 2015

⁵play.google.com/Store

⁶[https://developer.android.com/studio/](http://developer.android.com/studio/)

build tools. In order to facilitate collaboration between the two developers, the Git Version Control System was used. The Git repository was hosted online by GitHub⁷.

4.3.3 Testing

Due to the nature of the application, which generally displays information whilst seldom having to compute results, there was little need for extensive automated testing. That aside, the JUnit unit testing framework⁸ was used to test appropriate functions. The other features and functionality were tested by manually executing all conceivable tasks and work-flows, and monitoring the application for bugs, errors, and warnings using the Android Debug Bridge.

4.4 Co-Design

The co-design process consisted of three iterations of a *design, prototype, and evaluate* cycle. Each iteration of the cycle resulted in a higher-fidelity prototype than the last. The first iteration produced a low-fidelity paper prototype. The second iteration produced a working mobile application, with all of the core functionality implemented. The third, and final, iteration of the cycle resulted in a refined mobile application, with the remaining features and functionality completed.

4.4.1 Motivation

We opted for a co-design process for a variety of reasons. Firstly, we essentially had two different clients, namely Milk Matters and their donor mothers, who had different needs and requirements with regards to the application. It was thus necessary to reach a compromise on all fronts, and the collaborative nature of the co-design process allowed us to do so. Secondly, whilst it was essential that our application was aligned with Milk Matters as an organisation, the application's end users would actually be the donor mothers. As such, it was critical that we built an application that is as close as possible to what they would want it to be. This meant not merely capturing mothers' desired functional requirements, but also the non-functional requirements and general design that would make the application most valuable and useful to them. Once again, the co-design process allowed us to capture, and cater to, the needs and wants of both Milk Matters and their donor mothers, and provided us with a few attempts at achieving a best-effort prototype.

4.4.2 Strategy

Initial Meeting with Milk Matters.

The project was initiated with a meeting with Milk Matters. The aim of the meeting was to identify Milk Matters' needs and requirements for the mobile application, and gain an understanding of their organisational activities, operations, and constraints. These needs and requirements were then translated, in collaboration with Milk Matters, into a proposed set of functional and non-functional requirements for the application. The meeting was also used to discuss the project time-line and milestones, and establish a plan for recruiting and interacting with donor mothers as participants in our study. It was agreed that the initial recruitment of, and interaction with, participants would be handled by Milk Matters, primarily via mass and personal emails.

⁷<https://github.com/>

⁸junit.org

Brainstorming and Prototyping Workshop.

After the initial meeting with Milk Matters, we arranged a brainstorming and paper prototyping workshop with donor mothers. This, combined with the initial survey described below, comprised the first iteration of the *design, prototype, and evaluate* cycle. It must be noted that only two mothers were able to attend this workshop. Many mothers indicated that they were interested in participating in our study, but could not attend such a workshop due to logistical difficulties. The aim of the workshop was to gain an understanding of what donor mothers would need and value in such an application, and get feedback on the paper prototypes we had designed, based on the information attained in the initial meeting with Milk Matters. We initiated the session by explaining the aim of the project, and generally what we hoped to achieve. We did not divulge details of the needs and requirements we had identified with Milk Matters, or show the mothers the paper prototypes we had developed, as we did not wish to bias their thinking. We then encouraged the mothers to share their experiences as breast milk donors, and in particular with Milk Matters.

Once we had a general understanding of their experiences and context, we facilitated the brainstorming component of the workshop. In this brainstorming session, the mothers were prompted to share what would: be required by them of such an application, be valuable and useful, not be appropriate in such an application, motivate them to donate, improve their experiences as breast milk donors, and improve their interactions with Milk Matters. The focus questions were kept as broad as possible, and we refrained from leading the mothers down any particular avenue of thought, in order to gain a true understanding of their actual thoughts, needs, and wants. The mothers were then asked to rank the features and functionality they identified in order of importance. Following the brainstorming component of the session, we introduced the mothers to the proposed features and functionality we had identified in the initial meeting with Milk Matters, and showed them the resulting paper prototypes. The mothers were then encouraged to critique the paper prototypes. At this stage in the design process, we had opted for low-fidelity paper prototypes. The disposable nature of these prototypes prevented us from over-committing to any design, or deterring the mothers from honestly and completely critiquing them.

Initial Survey.

Due to the low turnout at the brainstorming session, yet willingness of mothers to participate, we opted to distribute a survey enabling mothers to share their thoughts and opinions on what the Milk Matters mobile application ought to be. The outcomes of the brainstorming session and proposed content of the survey were discussed in a follow-up meeting with Milk Matters. The survey was then distributed by Milk Matters, via email, to the mothers on their mailing lists. Mothers were provided with a blurb describing the application in general, as well as each component thereof and its proposed features and functionality, and asked to answer a series of questions. Mothers also had access to the paper prototypes, should they have desired a visual description of the proposed components of the application. The survey made use of both close and open-ended questions, and resulted in both quantitative and qualitative data. Most of the questions asked mothers to respond using a 5 point Likert scale,

in order to facilitate quantitative comparability between the mothers' responses for any particular question. The same set of questions was used for each component of the application, in order to facilitate the direct comparison of the mothers' responses for the various components. Mothers were also given the option to comment freely on all components of the application, thereby allowing for qualitative feedback.

Follow-Up Interviews.

Having redesigned the application based on the feedback we received, we hosted follow-up interviews with the donor mothers from the initial workshop. This comprised the second iteration of the *design, prototype, and evaluate* cycle. The aim of these interviews was to evaluate the second prototype, which took the form of a mostly complete mobile application. We opted to perform a cognitive walk-through with the mothers, in which they were required to complete certain tasks with the application, and encouraged to think aloud as they did so. The tasks were designed to assess the usability of all facets of the application, and we refrained from assisting the mothers in their completion thereof. Following the cognitive walk-through, the mothers were asked a series of questions about the application, most of which were open-ended. This enabled us to attain a more complete understanding of their experience with, and perceptions of, the application, as well as suggestions for further changes. Based on the mothers' feedback, we redesigned the application for a second time, and implemented the remaining and additional functionality.

Follow-Up Survey.

The second redesign of the application produced our third, final, and highest-fidelity prototype: a complete application, ready to be used by mothers. A follow-up survey, which was intended to comprise the third iteration of the co-design process, was distributed to the mothers as a means of evaluating the third prototype. The survey was accompanied by a link to the application on the Play Store, allowing mothers to test it before responding. This follow up survey followed the same format as the initial survey, with screenshots of each component of the application for mothers who were unwilling or unable to use it. Unfortunately, at the time of writing this paper, the response to this survey was poor. As such, we have not reported on the results. Instead, we chose to evaluate the third prototype according to the feedback we received from Milk Matters during the final meeting, in which we showcased it to them.

4.4.3 Ethics

All the necessary ethical approval for the project was attained from the University of Cape Town's Ethics Committee. The correct ethical protocol was followed during any studies that involved direct interaction with donor mothers. In all situations, mothers were reassured of their anonymity. All mothers signed the ethical forms expressing their consent to participate in our study, and for us to audio record the session for our exclusive personal use.

5. DESIGN

5.1 General Look, Feel, and Behaviour

The mobile application adheres, as strictly as possible, to the Android design guidelines, principles, and best prac-

tices. The application is designed to look like a modern Android application, which makes use of Google's Material Design⁹. As such, extensive use is made of contemporary components such as Android's CardView. The application was also designed to mimic Milk Matters' website and other communication media, in order to make it easily distinguishable as the official Milk Matters mobile application. When the application is launched by the user, she is presented with the *home screen*, which contains various cards of information (see Figure 1a). The cards present the user with summary information from a few of the application's main components, namely: the *donation tracking screen*, *news and events screen*, and *education section*. The user is able to switch between screens using the navigation drawer, which is the recommended and standard way to handle navigation between several screens (see Figure 1b).

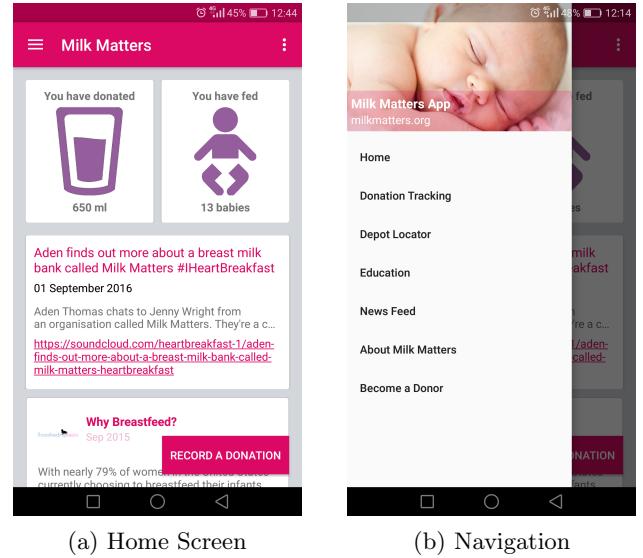


Figure 1: General Design

5.2 Donation Tracking

The *donation tracking screen* allows mothers to record and track their donations (see Figure 2a and Appendix A, Figure 7). Mothers are provided with summary statistics on the quantity of milk they have donated to date, and the number of babies they have effectively fed. The number of babies fed is calculated using a figure of 50ml per infant per day, which the mother is informed of on the application's first run (see Appendix A, Figure 10a). Mothers are also provided with more fine-grained information, in the form of a textual log of their donation history. In order to supplement the textual log with a visualisation, mothers can view graphs of both the quantity of milk they have donated and babies they have fed over time (see Figure 2b).

5.3 Depot Locator

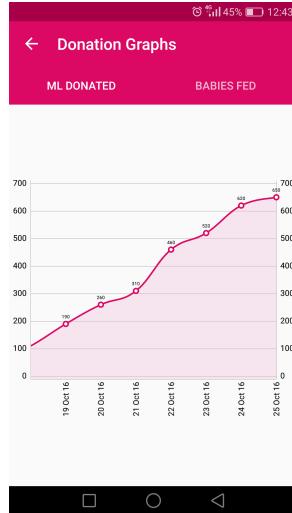
The *depot locator* makes use of the Google Maps API¹⁰ to provide users with an interactive map of Milk Matters' depots, and certain on-demand information about each particular depot (see Figure 3 and Appendix A, Figure 11).

⁹<https://material.google.com>

¹⁰<https://developers.google.com/maps/>



(a) Donation Tracking Screen



(b) Donation Graph

Figure 2: Donation Tracking

The *depot locator* also provides the user with functionality to automatically find her nearest depot. In order to prevent anybody and everybody from accessing information about Milk Matters' depots, the *depot locator* is password protected. As such, only registered donors can access the *depot locator* (see Appendix A, Figure 8).

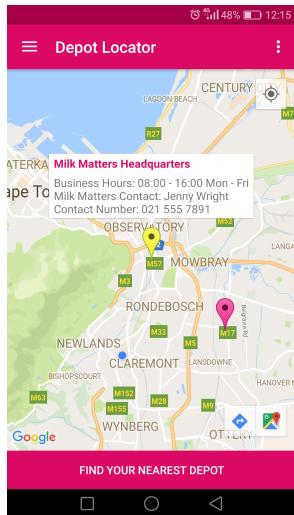


Figure 3: Depot Locator

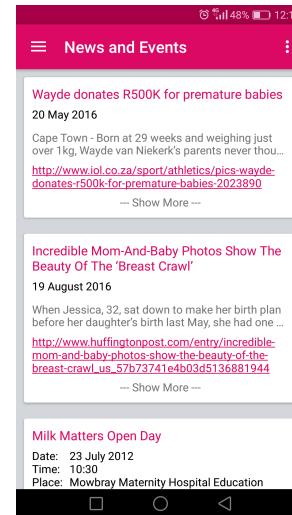


Figure 4: News and Events Feed

5.4 News and Events Feed

The *news and events feed* (see Figure 4) is designed to have a Facebook-like look and feel, with each news or event item being represented by a separate card. The main text of each card is restricted to two lines, in order to ensure that the feed is quick and easy to read. Should a particular item be of interest to a mother, she can click "Show More" to display the remainder of that item's main text. At the time of writing this paper, we had not yet developed a back-end for the *news and events feed*; due to time and resource



Figure 5: About

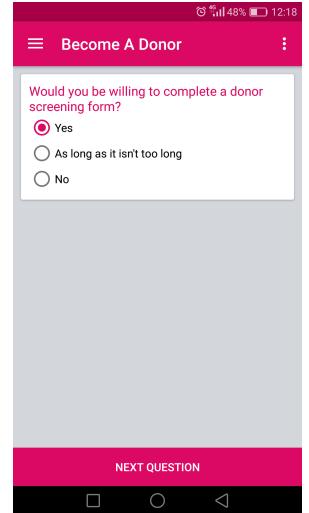


Figure 6: Become a Donor

constraints, it was deemed to be out of scope.

5.5 Education

The *education section* of the application will not be discussed extensively in this paper, as it is the focus of the application's co-author's paper¹¹. However, the features it offers are described briefly here, for the sake of completeness. The *education section* allows a user to choose from a variety of appropriate topics, such as nutrition, breastfeeding, and breast milk donation (see Appendix A, Figure 9a). Once the user has selected a topic, she is presented with a Facebook-like feed of relevant articles (see Appendix A, Figure 9b). Clicking on an article redirects the user to that particular article on the Website it was sourced from. All articles are vetted by Milk Matters, and sourced from reputable Websites that many mothers know and trust. Lastly, users are provided with an option to suggest an article, or topic, to Milk Matters that they deem relevant and would like to share with other mothers.

5.6 About Milk Matters

The *about Milk Matters screen* (see Figure 5) is essentially a central hub for mothers to learn more about, and get in contact with, Milk Matters. It provides mothers with a short blurb about Milk Matters, and easy links to: take the "*become a donor*" pre-screening quiz, view the Milk Matters Website, and phone or email Milk Matters directly.

5.7 Become a Donor

The *become a donor screen* (see Figure 6) provides mothers with a short pre-screening quiz. The quiz assesses a mother's eligibility to potentially be a donor, and the result of the quiz is strictly for the mother's own information. Questions asked include whether the mother would be willing and able to: complete a screening form, be tested for HIV, collect jars for donation, and drop off donated milk. After completing the quiz, the mother is presented with her result and a suggested course of action. She is encouraged to email Milk Matters using the link provided, which automatically generates an email based on her result. If she

¹¹See Chelsea-Joy Wardle's paper

is definitely not eligible to potentially be a donor¹², she is encouraged to make some other form of contribution. If she identified issues that do not necessarily preclude her from donating her breast milk¹³, she is encouraged to contact Milk Matters, as alternate arrangements could be made.

6. FINDINGS

6.1 Initial Meeting with Milk Matters

The initial meeting with Milk Matters produced a list of functional and non-functional requirements for the application (see Appendix B). Some of the functionality was deemed to be more critical than others. Important functionality included: a depot locator, an educational component, a donation tracking and visualisation component, a mechanism for Milk Matters to post news and announcements, and an about Milk Matters screen with easy links to get in contact with them. Less important, "nice to have", functionality included: a chat room for mothers and a pre-screening quiz.

In terms of the key non-functional requirements identified, Milk Matters were concerned about anybody and everybody with an Android device being able to access the content in the application. As such, they originally requested that mothers be required log in to access the application. Milk Matters were particularly concerned about making depot information public, partly in case mothers drop off excess milk without having gone through the proper screening process. However, once it was mentioned that protecting the entire application's content by password would hinder usage, and minimise the application's chances of converting prospective mothers into donors, this constraint was relaxed. Eventually, it was decided that only the depot locator needed to be password protected (see Appendix A, Figure 8). All other functionality would be available to anyone, regardless of whether she is a registered donor, as a means of marketing for Milk Matters, and in the hope that providing useful content to mothers might motivate them to become donors.

6.2 Brainstorming and Prototyping Workshop

The beginning of the workshop was used to gain an **understanding of the mothers' experiences** with donating breast milk, and Milk Matters. The mothers' responses were predominantly positive. Both mothers donated for altruistic reasons, and because they hoped that somebody would do the same for them and their babies. The mothers had little negative to say about their interaction with Milk Matters, other than that communication was often quite minimal. They indicated that they would appreciate more feedback from Milk Matters, but understood they were often short on time and resources. One mother did tell of one occasion on which her donated milk was not collected from a depot for a whole week; she said it frustrated her, and brought into question Milk Matters' apparent constant desperation for donated milk. However, she said it was not enough to deter her from donating. This story started a conversation wherein mothers stated that they would greatly appreciate being able to track their donations from the drop-off depot to the location at which they were used.

Once we had gained an understanding of the mothers' experiences, we facilitated a **brainstorming session**, in or-

der to discover what mothers would expect a Milk Matters mobile application to be; that is, what features and functionality they would need and desire in the application. In order to prevent mothers from being biased towards certain thoughts neither our, nor Milk Matters', proposed concepts or ideas were divulged at this stage. The features and functionality the mothers identified and deemed most important were: the depot locator, a mechanism for receiving news and announcements, and a way to view testimonials. Mothers stated that that they are particularly driven to donate by the testimonials, or "success stories", of children and mothers that have been helped, which are presently shared on Milk Matters' Facebook page. They emphasised the need for some form of depot locator, as having to constantly go to the specific depot they were assigned to is a logistical issue. Less important, but still highly desirable, features and functionality included; an educational component, some form of donation tracking mechanism, a way to share application content via social media, an FAQ, and a chat room or forum of some sort. The mothers were originally excited about the chat room/forum, but also acknowledged the difficulty of designing an appropriate medium for discussion, and the even greater challenge of mediating the discussion.

After the brainstorming session, the mothers **evaluated our paper prototypes**. The paper prototypes were met largely with approval. Mothers stated that most of the desired features and functionality were present, and that the prototypes appeared to be easy and simple to use. As such, there were no major changes requested to the included features and functionality, or the proposed design. However, it was at this stage in the workshop that the mothers identified various non-functional requirements, which they deemed essential. For instance, the mothers stated that it was crucial for the application to be easy to use with one hand, as they often tend to use their phones whilst breastfeeding, or performing other tasks which leave them with only one available hand. The mothers also identified an issue with the proposed *education section*, in that it was designed to include videos; the mothers stipulated that the application should contain no audio based functionality, as they were concerned about disturbing their babies.

6.3 Survey

The purpose of the survey was for mothers to evaluate our proposed features and functionality, which were derived from our initial meeting with Milk Matters and workshop with the donor mothers. Mothers were required to answer the same three questions about each proposed component of the application, using a 5 point Likert scale, and asked to leave an optional comment.

6.4 Follow-Up Interviews

Having completed our second prototype, a fully functioning application designed to meet the needs of mothers and requirements of Milk Matters, we hosted follow-up interviews with the two mothers from the initial workshop. The first phase of the interview was a cognitive walk-through. The most common difficulties the mothers experienced whilst completing the stipulated tasks were navigation related. Once the mothers managed to locate the appropriate screen/component for the completion of a given task, they typically managed to complete it with relative ease, and without problems.

Following the cognitive walk-through, we asked the moth-

¹²e.g. If she is unwilling to take an HIV test

¹³e.g. If she might not be able to collect jars for donation

Table 1: Evaluation of Proposed Features

	How useful would this be to you? 1 - Not useful at all 5 - Very useful	How much would this improve the donation experience? 1 - No improvement at all 5 - Vast improvement	How much would this motivate you to donate (more)? 1 - Not motivational at all 5 - Very Motivational	Noteworthy Comments
Depot Locator	Mean: 4.73 Mode: 5	Mean: 4.03 Mode: 4	Mean: 3.73 Mode: 4	1) Can help busy moms coincide milk drop offs... with baby check ups 2) Empowering to be in control of deliveries
Donation Tracking	Mean: 4.76 Mode: 5	Mean: 4.66 Mode: 5	Mean: 4.66 Mode: 5	1) Seeing how much you have donated and how many babies you have helped is an amazing motivator. 2) This would be awesome, I'd love this!
Education	Mean: 4.41 Mode: 5	Mean: 3.88 Mode: 4	Mean: 3.37 Mode: 3	This would be great. Most moms are looking up resources all the time.
News and Announcements Feed	Mean: 4.12 Mode: 5	Mean: 4 Mode: 4	Mean: 4.1 Mode: 5	Would be great to have a bit more real time info on where the milk is being used, and some little stories about the babies who are needing it.
Chat Room	Mean: 3.56 Mode: 4 and 5	Mean: 3.37 Mode: 3	Mean: 3.17 Mode: 3 and 5	1) It helps tremendously to feel connected to other mothers. 2) One needs to be careful with chat rooms - they require strict moderation if they are to work.

ers a series of questions about the application, and gave them the opportunity to comment and make suggestions. In general, the mothers were satisfied with the application, and felt that it met their expectations of what a Milk Matters mobile application ought to be. Both mothers agreed that the application appeared professional and aesthetically pleasing, and that it was simple, easy, and intuitive to use. The mother who was familiar with Android also agreed that it conformed to the expected look and behaviour of a modern Android application, whilst being easily identifiable as the official Milk Matters application. Both mothers felt that the user experience was consistent throughout the application, and that the application would most likely be useful to them, and motivate them to donate.

It must be noted that, in terms of the *donation tracking* component, the mothers felt that two disclaimers needed to be included. Firstly, the application needed to state how the number of babies they have fed is calculated. The mothers felt that merely knowing the exact figure would be motivational in itself; both mothers made reference to when they first learned the figure, and how it made them realise that they actually needed to do very little to make a big difference. Secondly, the application needed to make it clear that the information stored in the application is for their personal use only, and that it will not be sent to Milk Matters.

6.5 Redesign and Follow-Up Meeting

Having redesigned the application based on the feedback we received in the follow-up interviews, we met with Milk Matters. The purpose of the meeting was to showcase the third prototype, in the form of the revised application, and ensure that it satisfied Milk Matters' requirements, and could be made accessible to the public via the Play Store. Milk Matters were satisfied with the application, and felt that it

fulfilled their most important initial requirements, and exceeded expectations. Where their initial requirements and requests were not met, such as with the *chat room*, Milk Matters were in agreement that the functionality was, in hindsight, unfeasible or non-essential. Milk Matters were also in agreement that the implementation of a dedicated back-end for the application was similarly out of scope, given the time and resource constraints on the project. The changes requested were minor, and mainly pertained to the actual content of the application. For instance, they vetted the articles in the *educational section*, and asked for the opening hours of each depot to be removed from the *depot locator*.

7. DISCUSSION AND ANALYSIS

7.1 General Design

The general design of the application was met with positive responses from both our client and end-users. They were in agreement that the application looked professional and was: aesthetically pleasing, easy and simple to use, and consistent with modern Android applications in terms of appearance and behaviour. This was particularly important, as we aimed to minimise the learning curve associated with using the application, knowing that many mothers do not have the time or energy to learn to use a complicated or unfamiliar interface.

7.2 Evolution of Features

This section discusses the evolution of the various components of the application throughout the co-design and development process. Fortunately, there was minimal conflict between Milk Matters' and their donor mothers' needs and requirements, and there were no drastic changes to the initial core functional requirements. Instead, the co-

design process revealed more previously unconsidered non-functional requirements, and design constraints and considerations, unique to a user group of mothers of infants and young children. Our use of an agile development methodology ensured that we were well equipped to handle these additional requirements, and the effects they had on the design of the application.

7.2.1 Depot Locator

The *depot locator* was originally intended to merely provide mothers either with a map or list of depots, and we expected it to be perceived by mothers as a "nice to have" feature. However, based on the feedback we received from the brainstorming workshop and initial survey, it quickly became apparent that it was a highly sought after feature amongst donor mothers (see Table 1). In general, mothers felt that it would be very useful to them. They seemed particularly attracted to the prospect of being able to drop off their breast milk at their convenience, as opposed to at the single depot Milk Matters designated for them. The mothers also requested that the depot locator display extra information about each depot, such as the opening hours, contact number, and Milk Matters contact person. Knowing the name of the Milk Matters contact person would prevent mothers from having to awkwardly arrive at a depot and enquire about who they ought to drop off their breast milk with, an experience shared by both mothers in the brainstorming workshop. The mothers felt that the donation process would be considerably more pleasant and personal if they could build rapport with these Milk Matters contacts, which the depot information might enable them to do. As such, it seems that the *depot locator* would make a significant contribution to eliminating some of the inconvenience associated with, and impersonal nature of, donating to a human milk bank. This could, in turn, increase the supply of donated milk to a human milk bank, such as Milk Matters.

7.2.2 Donation Tracking and Visualisation

The *donation tracking* component was always intended to be a main feature of the application. This was supported by mothers' positive responses in the brainstorming workshop, survey, and follow-up interviews. Whilst it is not a necessity, mothers felt that it would be a "cool" and "fun" addition to their donation experiences. It was encouraging to note that most mothers thought it would be both very useful and motivational. This feedback suggests that mobile technology can indeed be used to motivate human breast milk donation.

Despite its popularity, the content of the *donation tracking* component of the application was frequently a topic of discussion and debate. It was always clear that a textual donation history ought to be provided. However, it was often unclear what summary information and visualisations should be made available, and how they should be presented. For instance, should weekly, or perhaps monthly, totals and graphs have been available? These were difficult questions to answer, especially given the varying lengths of time for which different mothers donate, and the varying quantities of breast milk which different mothers are able to donate which, in turn, depends on what stage of the breastfeeding process a mother is in. Eventually, it was decided that all information and visualisations displayed would be based on a mother's cumulative donation history.

The reason for this decision was two-fold. Firstly, it al-

lowed us to avoid choosing a time scale appropriate for most donor mothers, which could be daily, weekly, monthly, or something in between. Secondly, and most importantly, it prevents a mother from ever having the perception that she is donating less than she used to. Even if all mothers are aware that they will eventually be able to produce, and thus donate, less breast milk, it could be detrimental for a mother to feel like she is helping less day on day, week on week, or month on month. Such a realisation might discourage her from donating, or diminish the charitable feelings of significance and worth she experiences when donating. This would naturally be counterproductive to the ultimate aim of the application. Instead, all statistics and graphs displayed to a mother are cumulative, so that she constantly experiences positive reinforcement, and has the perception that she is continually donating and helping more.

Whilst designing the *donation tracking* component, we considered allowing mothers to set goals for their donations. This feature may have been favoured by some mothers; however, we were concerned it would create the opportunity for unhealthy competition and disappointment, or encourage mothers to donate more to the detriment of their own children. Mothers also desired a way of sharing their achievements on social media, but this feature was not implemented for the same reasons as the last. It was whilst discussing these features that we noticed that some mothers were, interestingly and perhaps uncharacteristically, competitive. Some of the mothers were competitive with both themselves and others, and stated that their competitive nature would motivate them to donate more. In fact, one mother even expressed interest in a Milk Matters donor mother leader-board. However, it can be argued that whilst competition might motivate some mothers to donate, it would do the exact opposite for others.

Another consideration for the *donation tracking* component was whether it should send donation tracking information to Milk Matters. We quickly decided against sending the information to Milk Matters. Firstly, building the back-end for such a system was beyond the scope of this project. Secondly, we were concerned about the privacy of mothers, and how they might feel about their personal information being sent to Milk Matters. In order to make it clear that this would not happen, we included a disclaimer in the application (see Appendix A, Figure 10b). A related, interesting improvement, which is likely not feasible but would be highly desirable to mothers, would be for Milk Matters to respond to the donation tracking information sent from the application by informing a mother as to when and where her donated milk was used. This would make the process of donating to a human milk bank considerably more personal, and thereby eliminate one of the issues mothers have with donating to human milk banks.

7.2.3 News and Events Feed

The *news and events feed* was, arguably, meant to be a bigger feature of the application than it ended up being. Other features were prioritised due to the comparatively lacklustre response it received in the brainstorming workshop and initial survey. We suspect this response may have been partially a result of the fact that mothers already have access to a very similar source of information, in the form of Milk Matters' Facebook feed. As such, much of the content provided would have been duplicated from the Facebook

feed. Being able to access this content in the application would thus have been convenient for mothers, but arguably offered no new value or motivation to donate. This also contributed to our decision not to prioritise building a back-end for the *news and events* feed.

7.2.4 About and Become a Donor

The *about* screen, whilst important, was one of the least interesting components to design and build. Based on the mothers' feedback, it served its purpose of providing them with basic information about, and multiple ways of getting in contact with, Milk Matters. The *become a donor* quiz was, arguably, more interesting. It was actually suggested by us, based on our assumption that prospective donors may want a quick and easy way to self-assess whether they may be eligible to donate, without going to the trouble of contacting Milk Matters and being screened properly. Milk Matters were instantly fond of the idea and allowed us to implement the quiz, based on the understanding that the questions had to be chosen carefully, and it had to be made abundantly clear that the quiz is not part of the official donor screening process. Part of our original rationale for including the quiz was that it is an interactive addition to the process of becoming a donor, and encourages mothers to contribute in other ways if they are ineligible to donate breast milk.

7.3 Sensitivity

The process of designing for, and with, mothers of young children was quite unlike that of most other software engineering projects. The constraints and demands on mothers had far reaching implications for both the co-design process, and our software product. Firstly, co-ordinating with mothers of young children to partake in a study was often logistically difficult. Many mothers were simply unable to partake in person, even if they wanted to. As such, we had a much better response to digital means of participation. Secondly, hosting workshops, cognitive walk-throughs, and interviews was often difficult with babies present. The frequent breastfeeding breaks alone were certainly uncommon with respect to most other co-design projects. That being said, the presence of the babies during the cognitive walk-throughs did, arguably, result in a more authentic reflection of the mothers' would-be experiences with using the mobile application. In terms of our actual software product, the constraints and demands on mothers resulted in numerous non-functional requirements. For instance, as mentioned, the mothers requested that the application did not contain any audio, and that it was easy to use with one hand. These are both requirements that a regular software developer would probably not have identified, and for which credit must go to the iterative co-design process.

7.4 Limitations

The main limitation of this study arises from the nature of working with mothers, and particularly mothers with young children. Due to the constraints on mothers' time and energy, few mothers were able to commit to physically attending workshops and interviews. In fact, only two mothers managed to attend the initial workshop and follow-up interviews. However, we did not deem this to be a major issue, since the two mothers that attended provided us with sufficient feedback and suggestions. In order to compromise for the low attendance at these sessions, we sent out two

comprehensive surveys that were primarily aimed at evaluation. The first survey achieved 41 responses. However, as mentioned, the second survey was met with a poor response, and the results were consequently omitted from this paper. It must, therefore, be noted that this work might not be representative of the opinions of most donor mothers.

8. CONCLUSIONS

We deemed the Milk Matters mobile application to be a success for various reasons. Firstly, from a software engineering perspective, the application satisfied the majority of both our client's and end-users' most important functional and non-functional requirements. Where requirements were not met, Milk Matters were in agreement that the relevant functionality was unfeasible and/or non-essential. Secondly, it appears that the mobile application met the expectations of both Milk Matters and their donor mothers, based on the predominantly positive feedback we received. As such, it can be reasonably concluded that the iterative co-design process, coupled with an agile software development methodology, enabled us to balance and fulfil the needs and wants of both our client and end-users effectively. In addition, the project was a success from a design point of view. It was agreed that the application looked professional and was: easy and simple to use, aesthetically pleasing, and consistent with modern Android applications.

Arguably most importantly, based on the responses of the mothers who participated in our study, it appears that the Milk Matters mobile application would likely motivate mothers to donate their excess breast milk to a human milk bank, and increase their donations where applicable. Similarly, mothers indicated that the application would improve their experiences as milk donors. The Milk Matters mobile application, and by extension this project, was thus a success, as it would likely achieve its ultimate aim of motivating mothers to donate their excess breast milk, and thereby increasing the supply of breast milk, to human milk banks.

9. FUTURE WORK

Potential future work for the Milk Matters mobile application itself mainly involves the back-end. At present, there is no formal, dedicated back-end which allows Milk Matters to easily update application content, such as the news and events or depot information. It would also be ideal if the back-end had a GUI, which would make it simple for Milk Matters to generate content for the application. Finally, there still needs to be research into the extent to which such a mobile application actually does motivate mothers to donate their excess breast milk, and thus increase the supply of breast milk to human milk banks. Due to the short time frame of this project, and the numerous factors which influence both an individual mother's and the aggregate supply of breast milk, we were unable to obtain empirical evidence to support any conclusions on the matter. As such, this research remains as future work.

10. ACKNOWLEDGMENTS

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APPENDIX

A.

SCREENSHOTS

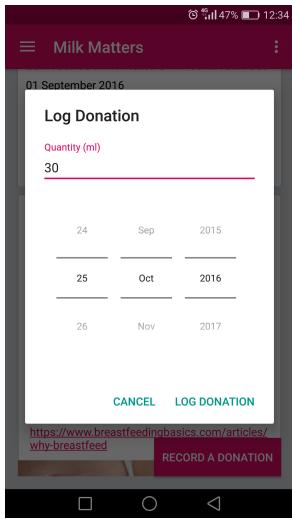


Figure 7: Log Donation

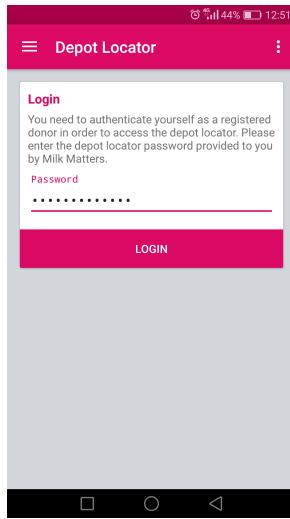
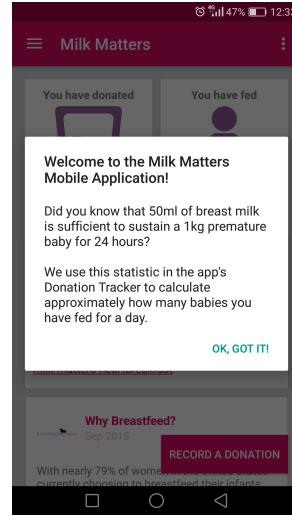
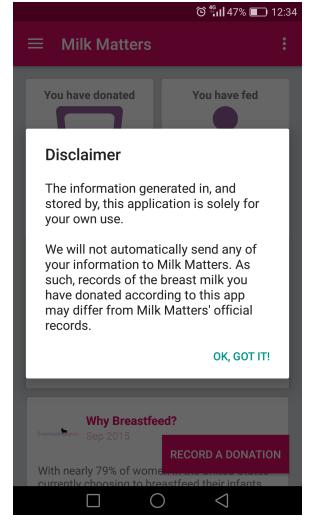


Figure 8: Depot Locator Login



(a) Welcome

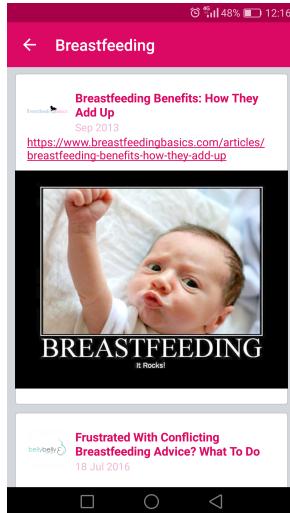


(b) Disclaimer

Figure 10: Disclaimers

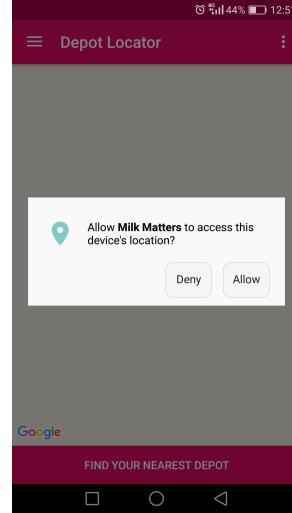


(a) Choose Topic

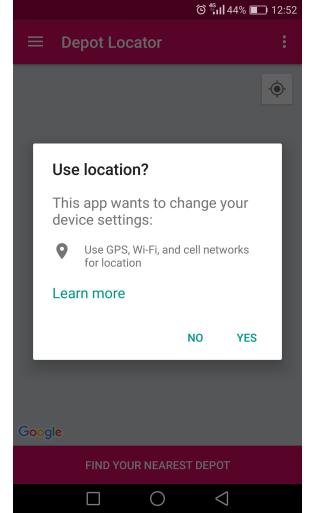


(b) Articles

Figure 9: Education



(a) Allow Location Access



(b) Use Device Location

Figure 11: Depot Locator Permissions

B.

MILK MATTERS' REQUIREMENTS

Milk Matters' initial **functional requirements** for the mobile application were as follows. The mobile application should:

- Have an educational aspect. This may include lessons and diagrams on the pumping process, how to donate, increasing milk production, how to massage the breast, and how to get a child to latch.
- Provide mothers with donation tracking and data visualisation functionality, particularly with respect to quantities donated, their contribution over-time, the impact of their donation, and their baby growth.
- Inform mothers about locations for dropping off their donations (depot locator).
- Provide functionality for Milk Matters to make notifications and announcements to mothers via the app.
- Host a chat room for mothers to interact anonymously with one another.
- Have some sort of pre-screening quiz or form.

Milk Matters initial **non-functional requirements** for the mobile application were as follows. The mobile application should:

- Reassure mothers about the rate of their donation, and remind them not to neglect their own child.
- Provide mothers with information about Milk Matters, and quick links to get in contact with them.
- Promote the donation of breast milk to human milk banks, or any other contribution like equipment, money, or partaking in charity events.
- Only provide mothers with positive feedback and reinforcement about their donations.
- Be sensitive to the needs of mothers, and avoid anything which might discourage them from donating.
- Avoid any features or content which may create unhealthy competition, or motivate mothers to donate their breast milk to the detriment of their own child.
- Ensure that the depot locator is only accessible to registered donors.