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Developing mHealth Solutions for Natural Family Planning

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DEVELOPING mHEALTH SOLUTIONS FOR
NATURAL FAMILY PLANNING

by

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A Thesis submitted to the Faculty of the Graduate School,
Marquette University,
in Partial Fulfillment of the Requirements for
the Degree of Master of Science

Milwaukee, Wisconsin
December 2013

ABSTRACT

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Natural Family Planning (NFP) is a method to help couples determine the fertile and infertile times of a woman's menstrual cycle with natural indicators of fertility. NFP methods have advantages over other methods of family planning. Proper use of NFP methods also ensures high effectiveness (close to 98%) in helping couples avoid pregnancy. However, very few physicians prescribe NFP to their patients due to lack of credibility to the fertility methods and lack of access to NFP knowledge. The Marquette University College of Nursing Institute for Natural Family Planning has been researching for many years to increase knowledge and efficiency of NFP. Their proposed evidence-based Marquette Model (MM) for NFP already showed success as an internet based charting system. It is obvious to have an effective mHealth (mobile health) solution for NFP because of enormous growth of smart phones. We have designed and developed muFertility, a mHealth framework that follows the MM so that couples can chart the menstrual cycles. In this thesis, we have discussed the major human computer interface (HCI) and design issues. We also have also presented how user feedback cycle based approach can be used to incorporate user experiences in the development and deployment of a mHealth solution.

ACKNOWLEDGEMENTS

Md Miftah Uddin

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BBT	Basal Body Temperature
HCI	Human Computer Interaction
mHealth	Mobile based Healthcare
MM	Marquette Model for Natural Family Planning
NFP	Natural Family Planning
LH	Luteinizing Hormone
STM	Sympto-Thermal Method

CHAPTER 1: INTRODUCTION

The term Natural Family Planning (NFP) is used to generally indicate various methods of family planning that are developed to help women and men determine the fertile time's of a woman's menstrual cycle. Couple's can use these methods to avoid or achieve pregnancy. Natural methods to avoid pregnancy have been practiced from ancient times. However, modern methods of NFP are becoming increasingly popular in the modern age because of its increasing effectiveness [1] and because there are no harmful physical side effects with its use. Using NFP methods also increases fertility awareness. The practice of NFP actually confers married life a higher human value and increases communication between men and women. There are many methods for applying NFP in real life. These methods use some form of natural fertility indicator through women menstrual cycle. Calendar rhythm, Basal body temperature (BBT), Ovulation method (OM), Sympto-thermal methods (STM/SM), Hormonal monitoring method are some of the popular methods. However, most of the methods are very complex by nature to ensure it is handling all natural variability in menstrual cycle and providing efficiency for reliability in order to compete with other methods of family planning. It requires expertise of fertility and natural fertility indicators and continuous supervision from some NFP expert as well. This reduces people's interest in practicing these methods.

In United States of America only 64,000 to 124,000 couples are currently using modern natural family planning methods to avoid or achieve pregnancy. Though NFP is effective and has some advantages still it is not practiced hugely in USA. Fehring and Jones in their research identified major reasons include lack of access to qualified teachers, actual and perceived ineffectiveness and lack of credibility of the methods

among health professionals, nurses and general public. [16]. It is clear that practicing NFP methods can be increased with spreading knowledge and ensuring ease of use. An approach towards achieving this goal can be proper use of information technology.

Marquette University College of Nursing Institute for Natural Family Planning launched a federally funded "Effectiveness Study on Two Internet-based Natural Family Planning Methods" In February 2009. The pilot project was targeted for couples wishing to avoid or achieve pregnancy by charting their vital fertility signs [15]. Two methods (hormone based & mucus based) were randomly assigned to the couples registered to the system. The study shows that the acceptability and effectiveness for the internet based system increased in the pilot study [4] but the number of responses decreased with time. It is clear that the internet based system was able to provide effective service to its users, however it wasn't able to be used as a part of daily life to the modern fast paced technology based society who are more used to Smartphone and feel comfortable using them because of their portability and ease of use.

In the modern age of technology using handheld devices are becoming more popular than ever. People are feeling more comfortable to access or exchange of information using mobile phone applications than doing same service with any other method (paper based or internet based or any others means). Because of large number of sensors and ease of use Mobile based healthcare (mHealth) is also envisioned for becoming one of the largest focuses for the industries. As of 2013, 95 million Americans are using mobile phones as health tools or to find health information, according to Manhattan Research. This is 27% higher than 2012, when the number was 75 millions [12]. There are lots of available smart phone applications for monitoring women's

menstrual cycles to avoid or to achieve pregnancy or as a vital sign for health. However, most of the applications only focus on a single fertility indicator and/or simple user interface designs.

Designing a mobile application for NFP requires involvement of NFP experts and reliable feedback from its users. It requires background research and collaboration with health professionals and specialists on relevant health topics. Also a considerable issue for application development is that people who will be using the application are considered as they don't have any prior knowledge about NFP or fertility markers. Therefore the application designs need to have a very simple interface and learning methods along with a good source of knowledge for fertility awareness. The NFP model for the application should also cover all variability and have the ability to handle exceptional cases to satisfy all of its potential users. Generally couples will use the application every day; therefore application user interaction design should satisfy major Human Computer Interaction (HCI) issues. Also to improve user experience the development strategy must have an iterative process for continuous feedback and modification. The data entry system in the app for everyday has to be quickly accessible so that the application can be operated every day in a minimum amount of time. On the other hand regardless of the device data representation in the application the interface should be designed to bring a clear picture of the current status of the menstrual cycle to the users.

To implement the Marquette Model for NFP we have developed an iPhone application that we named muFertility. It is funded by a grant from the Institute of Natural Family Planning at Marquette University. The Marquette Model used in the

application is a combination of hormone based monitors, basal body temperature and cervical mucus as indicators of fertility. In this thesis we mainly focused our discussion on the design considerations and how we addressed those while implementation. We also discuss how the user feedback based development model contributed throughout the development process and improved the application interfaces from the user's perspective. We also discussed how we have implemented the considered issues and the way these issues solved the problems in real life.

CHAPTER 2: BACKGROUND

Natural family planning has been practiced since ancient time. It is found that early Greek Physicians practiced a form of natural family planning method. The Greek physicians were able to define fertile and safe period of women. Also many types of potions and behaviors for the purpose of contraception were prescribed by the Saraons. Anthropologists also found use of natural signs of fertility in ancient African aboriginal tribes and Australia. Natural Family Planning is also practiced among traditional Jewish because they found it religiously influencing. Eventually the world of NFP gave rise to the monitoring cervical position and mucus in the modern age. The World Health Organization conducted studies to further validate the efficacy of these new methods such as the Billings, and Kipply's methods. In the 1970's Dr. Thomas Hilgers begun to do research on the Billings Method and created the statistically validated Creighton Model.

2.1 NFP Methods

There are several biological markers for NFP. Selection of biological markers depends on accuracy, cost and ease of use. Among the markers cervical mucus is most focused. At different stages of menstrual cycle the mucus can be clear stretchy and/or lubricative (slippery). The self-measurement of the urinary luteinizing hormone (LH) surge is another widely used and available marker of fertility. Self-measurement, however, requires use of test strips for urinary assays and/or fertility monitors and renewal of test-strip supplies. The basal body temperature (BBT) method is less accurate compared to other two methods.

1. Calendar Rhythm: Calendar Rhythm is based on the length of the shortest and longest length of the past cycles. This method is comparatively easy to use but has less accuracy.

2. Basal body Temperature (BBT): This method is followed by tracking the daily waking temperature of women through her menstrual cycle.

3. Ovulation method: Ovulation method requires tracking the characteristics of Cervical Mucus. The patterns of cervical mucus can be categorized to beginning, peak and end of the fertile cycle. This is one of the complete indicators of fertile phase.

4. Sympto-Thermal methods (STM//SM): It is a combination of BBT and Cervical mucus (Ovulation method)

2.2 Marquette Model for NFP

To ensure the reliability and efficacy of NFP for physicians and their patients NFP methods mentioned above need's to provide evidence for their efficacy and usability. Unfortunately all the methods and their related calculations are complex for couples to follow everyday for themselves. A better approach is required to make the methods applicable with defined calculation and different circumstances. The Marquette Method (MM) proposed by College of Nursing Institute of Natural Family Planning is a new system of NFP that utilizes one or more of the biological markers of fertility [14]. It combines electronic hormonal fertility, basal body temperature, and changes in cervical mucus. A woman's menstrual cycle can be divided into three phases pre-ovulation, ovulation and post-ovulation [8]. During the phases of a woman menstrual cycle a man and woman together are fertile for only 6 days. The timing and length of these six days

(also known as fertile window) for ovulation can vary from cycle to cycle. Post-ovulation phase is the most stable phase of a cycle; whereas pre-ovulation phase is the most variable phase. The calculation for the beginning and end of fertility differs for the first 6 cycles and for the cycles after first 6 cycles.

- Beginning of fertility
  - For the first 6 cycles: fertility begins on day 6
  - After 6 cycles: fertility begins on peak day of last 6 cycles minus 6 days or days for first high or peak reading, whatever comes first
- End of fertility:
  - For first 6 cycles: Fertility ends 3 full days after "peak" day
  - After 6 cycles: Fertility ends 3 full days after the last "peak" days of the last 6 cycles

    or last peak days plus 3 full days of current cycle whatever comes first [8]
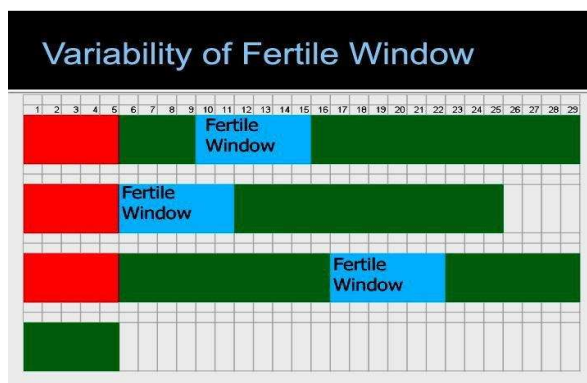
Figure 2.1: Variability of menstrual cycle phases

2.3 Online Cycle Monitoring

The Marquette Institute of Natural Family Planning has developed online fertility monitoring system. Over 3,000 women have or are using the online fertility monitoring system. They have online discussion board to have conversation with the health professionals and NFP consultants. This system guides its users for avoiding or achieving pregnancy and also increases their fertility knowledge following Marquette Model (MM). In the online charting system women can monitor the phases of their menstrual cycles, their estimated fertile window, and other signs that might indicate health problems (e.g., unusual uterine bleeding). The users are also able to monitor symptoms and notes every day. With the user input the system calculates the fertility window and indicates it with color. All cycles are saved in database; therefore a user can view their past/completed cycle history.
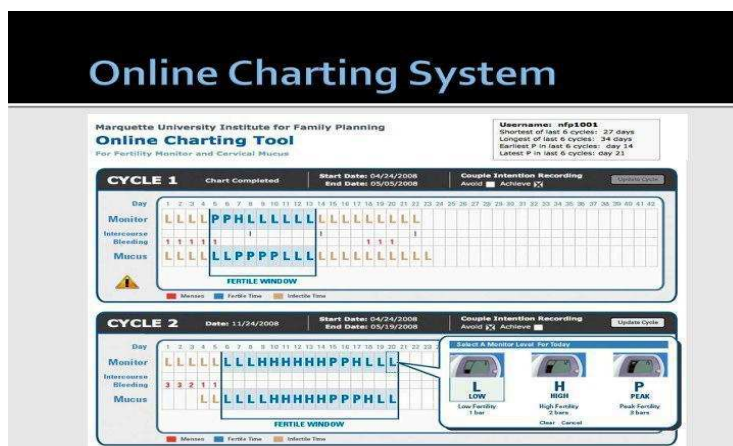
Figure 2.2: Online charting for Marquette Method

The online fertility tracker also has a discussion forum where registered users can share their cycles and consult with fertility experts, professional nurses and physicians.

CHAPTER 3: RELATED WORK

The demand for Natural Family Planning and fertility monitoring (in particular for couples wishing to achieve pregnancy) is increasing. A mobile fertility monitoring device with smart touch screen also makes it easier to implement for end users with complete functionality. There are not many institutions or health centers that already have mobile applications for NFP. The two top mobile application market places, Apple's Appstore and Google's Playstore for app, have few applications for NFP. Most of the applications in the market places are published in the application market places in recent years. We are discussing some top application among them.

3.1 Kindara Fertility Tracker

Kindara Fertility Tracker is an iPhone application by Kindara Inc [10]. The application has a very simple data system. They also provide fertility education to increase fertility awareness. Within one year after their first launch they already have more than 200,000 users. The application requires monthly and yearly subscription charge. With Kindara application a user can only monitor their cycle cervical mucus or BBT.

3.2 Fertility Friend

Fertility Friend by Termits Web Services Inc. is very nice and clear application [11]. It uses calendar based method for ovulation charting. It also contains education materials to increase the knowledge and confidence of its users. This application saves its data to cloud. But to always keep in sync with the online data, users needs to be online while using it. It has a unique functionality cycle comparison where user can compare

two or more menstrual cycles. Additionally with this application it is possible to track and chart weight. This application particularly provides a lot of functionalities to its users. To provide a lot of functionality it is tough to use the application from the beginner level.

Application	Calendar	Simple screen	Research evidence	BBT	Secondary LH	Estrogen	Cervical mucus	Simplicity
Kindara Fertility Tracker	Yes	Yes	No	Yes	No	No	Yes	Medium
Fertility Friend	Yes	No	No	Yes	No	No	Yes	No
Monthly Cycles	Yes	Yes	No	Yes	No	No	No	Yes
muFertility	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 3.1: Fertility applications comparison

3.3 Monthly Cycles

Monthly Cycles from Deltawork is also a widely downloaded application [12]. They have both iPhone and iPad version. The application design is very simple and intuitive. The application is unique because it is able to make prediction for end of the fertile window and end of current cycle. Because of its simplicity the application is highly rated by its users.

All the applications discussed above have very clear interface design and are used by a great number of people. Still none of the application mentioned above are collecting

all the major fertility indicator parameters. Also for everyday use the data entry system is comparatively complex from multiple data input point of view. The applications which have simpler data entry methods have no way to view detail data status whereas application that are providing a detailed data view have complex data entry methods. A better method is also required in the field of NFP that is capable to consider all variability of fertility indicators and can be used as a simple application.

CHAPTER 4: OUR APPROACH FOR DEVELOPMENT

An entire smart phone application fertility monitoring system was developed with a combination of screens and a complete navigation system among those screens. To follow the Marquette Model which is a combination of hormone based monitoring, basal body temperature and cervical mucus based method, we have used agile development method that followed continuous feedback collection from its end users. We made the application interface versatile so that we can maximize the most of the user's satisfaction or willingness to use the application every day.

There are some major design considerations that we have listed to make the application match with its user emotion and implement the Marquette Model in an efficient way. After implementing the background model for the application we provided it to the users and listed their feedback. Additionally we have considered how feedback from the users changed over time. While the application development cycles running we found focus for users' feedback for the application changes overtime. At the beginning the users wanted the details of each control in the application but their expectation for details reduced because they have already used the application. When a user gets used to an application they want the navigation system to quickly access the most commonly used screens.

We viewed user experience from two perspectives, one way is viewing data and another is the data input system. At the beginning of the study he primary focus of the users was to the presentation of the data. When they get used to the application they become more focused to wanting a simpler data entry system. They started to focus on the decision of avoiding or achieving pregnancy more than the data representation and

fertility indication data view. The application for the NFP system is supposed to be used for daily data entry. A system with only proper functionality is not enough rather people who are using the application need to be connected with the application emotionally so that they use the application everyday with satisfaction. It is also important to make users feel that the application is reliable and meets their expectation as a tool for their family planning needs.

We have developed the application with user feedback based iteration. In general from the users' feedback we found though they feel the importance of application data view at the beginning of their use of the application, over time they get more interested in simplicity of data entry system. Usually once the confidence level is obtained that the application will provide necessary information to its user they started to put less focus on viewing the detail of data they have entered. So we made every data entry simpler and put current day data entry button on the home screen rather than putting the calendar view.

One of the key features of the Marquette Model is monitoring BBT. Monitoring the menstrual cycle with BBT is complex compared to other fertility indicators because there can be many reason that results in change of body temperature, e.g., stress, lack of sleep, and illness. Also the measurement of temperature needs to be accurate because calculation for fertility window can vary with a little change in temperature.
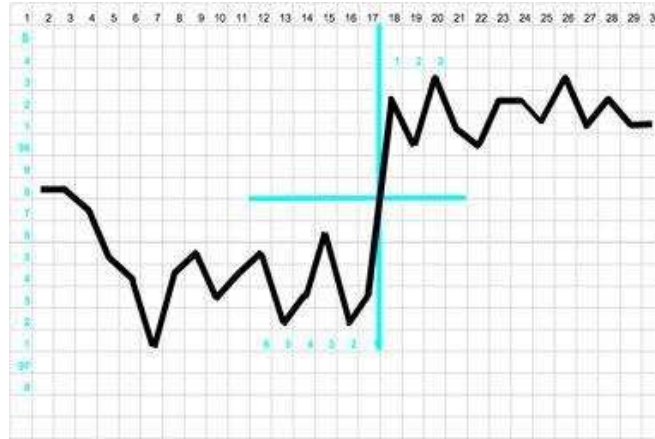
Figure 4.1: BBT curve for coverline method

We have followed the coverline method for monitoring BBT and determining the significant shift in temperature that indicates ovulation. The Cover-line Method is determined in the following manner:

1. Women need to use good (accurate) digital thermometer to record waking body temperatures for 10 consecutive days (beginning with the first day of menstruation). We locate the highest of these 10 recordings and above 0.1 degree Fahrenheit (Centigrade) of that temperature we draw a line

2. The woman continues to take and record temperature. The BBT will eventually rise above this coverline.

3. After the night of the 3rd consecutive temperature record above the coverline women will have their infertile phase. If one of the temperatures falls below then you should begin again to observe 3 consecutive temperatures. [7]

The bridge between an application and its users happened through it user interface. The satisfaction of an application depends on usability that is related with effectiveness and efficiency of the application and to let users perform a particular task. To be more specific about mobile application user interface and interaction design a big

challenge is fitting all the controls in the smaller screen of a mobile device. At the same time to meet the user expectation to perform every task the way they want. The application interface has to be intuitive and able to provide all functionalities. Positioning of buttons views and panels not necessarily needs to meet the efficiency rather it has to meet user's expectation and it has to incline the users to the application emotionally. While designing all the screens and navigation we kept this principle on high priority. There are more than 20 screens in the application including some screens with only text instructions. Among all the screens we consider a few with great importance since users spend almost 80% of their time with these screens while they are using the application.
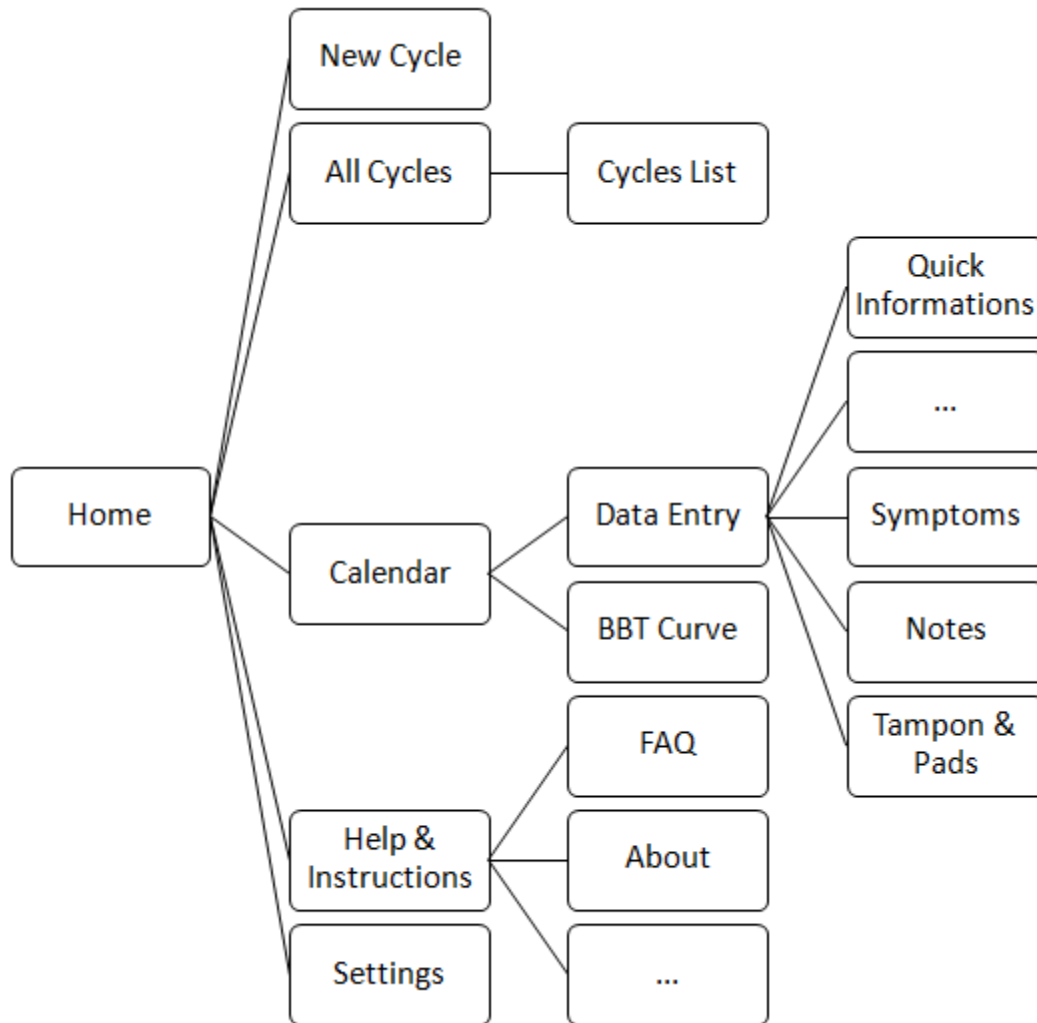
Figure 4.2: Navigation tree for muFertility

4.1 Home screen

The home screen is designed as a single point of operation for users of the

application. We have provided input buttons for most popular inactions. We have a

circular shape to give a quick graphical representation of the current menstrual cycle. In

the graphical presentation we display a maximum of 42 days length cycles. Less than

10% of women have their menstrual cycle greater than 42 days. Having 42 days makes it

clearer to view and understand. We have provided a single tap button to enter data at the

center of the home screen. When a user gets used to the application they use the home screen more frequently because they only want to confirm the status of their fertile window. The two main purposes of monitoring the menstrual cycle are avoiding or achieving pregnancy. We put the status message on top of the screen and highlighted it so that the user gets a clear idea about the fertile window regardless of their intention.

Figure 4.3: Home Screen

While using the application couples can change their intension of charting in the home screen. If a user taps on the "avoid or achieve pregnancy" button they will be able to change their charting intension in the middle of a cycle. A user can also complete their current cycle. We provided a complete cycle quick access button in the home screen.

4.2 Calendar Screen

The calendar screen has four layers of view: scroll layer, graphics layer, cell layer, and indicator layer. The scroll layer is provided to scroll through all 100 cells of a cycle.

The calendar cells layer contains all calendar cells associated with single tap and double tap action. The 2D graphics layer draws the fertile window around calendar cells to give a clear indication of the fertile window. The top-level cell data contains two indicators. The two indicators are for fertility indicators and intercourse.
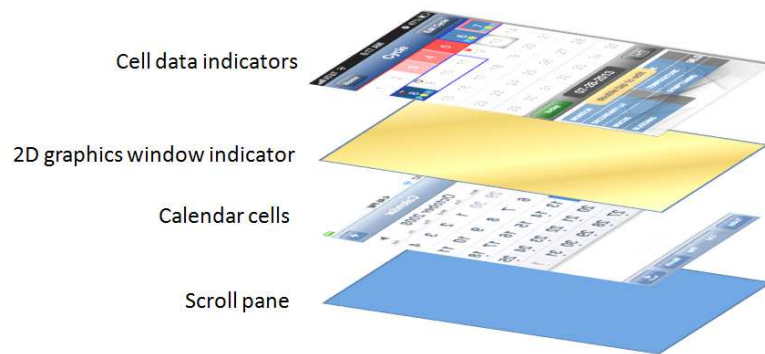
Figure 4.4: Calendar functional distributed layer

People are more used to see graphical representation rather than raw data values. We are showing graphical images on each cell. It makes the cells look busy that make the user confused and getting the real idea about the original data. We have separated the intercourse indicator and show it at the top position of a cell. Having intercourse is not a fertility indicator but intercourse information for a day is important because it is directly related to the issue of avoiding or achieving pregnancy. As we know, having intercourse within the fertile window will result in a high chance of achieving pregnancy and having intercourse outside the fertile window is safe for avoiding pregnancy. The calendar screen also includes a button to view the BBT coverline curve.
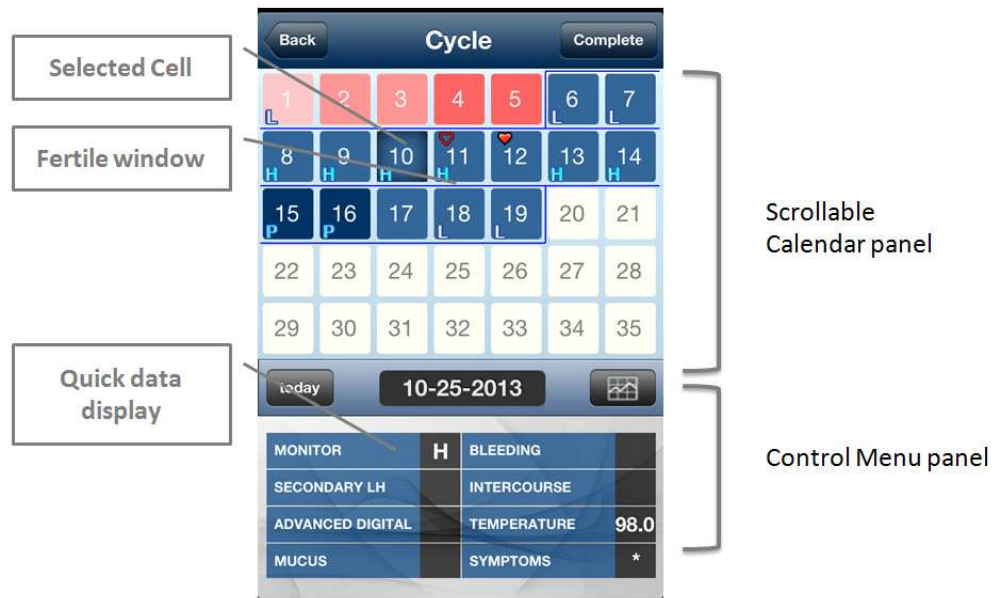
Figure 4.5: Calendar screen panels and controls

The dimension of a cell is an important issue. While designing the cell dimension and other properties we have to consider two major facts, we have to show as many cells at a time and we have to maintain the minimum cell size so that users will be able to tap the any cell with ease. According to apple's Human Computer Interaction guideline the dimension for any tap area should be minimum 42ppt. We kept the minimum size standard and provided scrolling to view rest of the cells.

A cell is associated with two actions. A user can view the data for a cell or they may want to enter data for that day. The single tap action for a cell is associated with data view at the bottom of the calendar cycle so that a user doesn't have to navigate away from the calendar screen when they view data for any cycle day. Data entry functionality is associated with double tap action. The data entry functionality has to be associated with every cell button because if we give another button for this purpose it may confuse the user. With any button other than the cell itself users have to change their focus from

the respective cell to that button and have to move their fingers to tap. That's why we brought the double tapping functionality. But the double tapping functionality has problem itself. Smart phone users are not generally used to with double tapping. Therefore we are showing a message to the user every time they are single tapping the button. This makes them adapt to the double tap functionality even if they don't have any idea about how to go to the data entry screen.
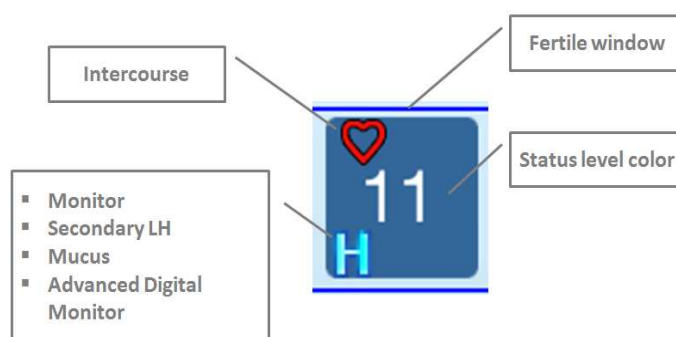
Figure 4.6: Cell graphical indicators in detail

At the primary stage of the application design we were showing all the fertility indicator data with graphical representation. Showing multiple indicator data in a single cell somehow makes the appearance of the cell complex and difficult to interpret. After getting the feedback that users are getting confused from the data representation we changed the original design and combined all fertility indicator data in one display parameter. We combined the data from the hormonal fertility monitor, the secondary LH test, the advanced digital monitor and cervical mucus into a single graphical indicator. The highest fertility level from any fertility indicator receives the priority rating among the input data of all the parameters. It gives the user a clear idea about the hormone status

for that day. The opportunity to view the data of each parameter is still available at the bottom of the calendar screen when the cell is single tapped.
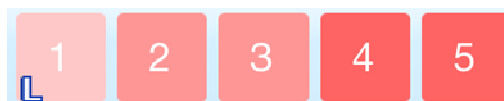
Figure 4.7: Color shade for different bleeding level

Menstrual bleeding levels indicated in the cells with a shade of red color. The shade on a cell gives a clear idea with a simple look so that user gets idea about data level without looking at the detail of data status. In the calendar screen fertile window is also indicated with a graphical layer that draws a blue borderline around the cells.

4.3 Data Entry Screen

The data entry screen actually gives the user the opportunity to input different fertility indicator data. All the indicators have their different panels. Every panel has a title indicating which parameter it is used for. Data entry screen is made scrollable to fit the different input parameters.

The hormonal fertility monitor in the data entry screen actually collects the status of the Clear Blue Monitor Data. The Clearblue Fertility Monitor is a small battery operated device [10]. It has a small window that provides the information for the current cycle day and the fertility status. It has a slot for fertility test sticks for the levels of the estrogen and LH hormones. If the couples are charting using the Clearblue monitor to monitor the daily fertility status of their menstrual cycle they have to use this indicator in the data entry screen. The monitor has three levels of fertility (Low, High and Peak

Fertility). To enter the data the user has to simply tap on the level button. The buttons are designed with the monitor screen photo.

Figure 4.8: Data entry screen

The secondary LH panel is used to input data for secondary luteinizing hormone with use of an ovulation predictor kit. If couples are following secondary LH for charting their menstrual cycle they have two buttons a plus sign (+) for positive and a minus sign for negative (-) to input results. The secondary LH panel also has a clear data button and quick information button. The clear button is provided to clear the data entered for a day.

Figure 4.9: Clearblue monitor

To monitor ovulation and the fertility status of a menstrual cycle, Swiss Precision Diagnostics (Geneva, Switzerland) the makers of the Clearblue Easy Fertility Monitor has introduced a new device called the ClearBlue Advanced Digital Monitor. In our data entry screen we also have a panel for the Advanced Digital Monitor. The Advanced Digital Monitor shows three kind of result on its screen, normal, flashing smiley face, and smiley face. The normal face equates with Low fertility, the flashing smile with High fertility, and the fixed smiley face with Peak fertility. We have provided three buttons with respective images like the Advanced Digital Monitor to make it easier to data entry.
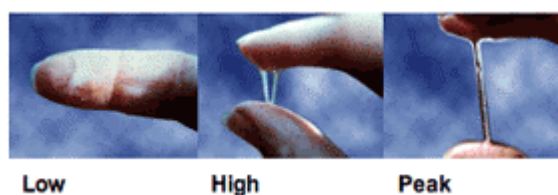
Figure 4.10: Different level of cervical mucus

Monitoring Cervical Mucus is one of the popular methods for fertility charting. We have included Mucus as the fourth panel in the data entry screen. Like the monitor, mucus is rated as L for Low, H for High and P for Peak based on the characteristics of the mucus. Each mucus button has a respective image to indicate how to rate the Mucus status. Like other panels Mucus also have a clear data and quick information button.

Basal body temperature is a unique data entry method where the user has to select a real temperature value for data entry. With temperature data entry a user can follow Basal Body Temperature (BBT) method. In the temperature panel we have a plus button to increase and a minus button to decrease the temperature value. The changes the temperature 0.1 decimal value of the Fahrenheit scales. Both Fahrenheit and Celsius

values are displayed in the panel. The default value for temperature is set to 98.6

Fahrenheit scale.

4.4 Symptoms and Notes

Monitoring menstrual cycle symptoms is also important for special situations. In

the symptoms window a user can select single or multiple symptoms they are having on

that particular day. Listing all symptoms needs a lot of space in the data entry screen. For

this reason symptom data input screen is separated in a different screen. There are three

categories of symptoms which are grouped in a table view in the symptoms screen. A

user can also save any special notes for each cycle day.
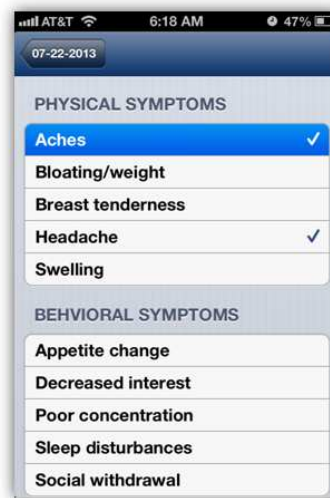

Figure 4.11: Symptom screen

4.5 Evolution of Interface Designs

There are two ways of interaction for touch based smart phone applications Swipe

based and Tap based. We have used tap based design everywhere. We made every user

interaction tap based so that users will not get confused about whether to have any functionality with swipe. We took feedback from users in all iterations of development and followed significant recommendation to improve the fertility monitoring application. Initially we designed the home screen as a control menu home with a set of buttons. After launching the first release we found the following issues from the users.

- Calendar screen is too complex to understand with a quick look

- For everyday use there is need for only one cell in the calendar among all the 100 cells

- Every time a user opens the application, they have to go to the calendar screen and select the current day cell and then enter the data from the data entry screen

To solve the issues, we have modified the home screen. The current day data entry button also shows a graphical representation of the calendar screen. The calendar screen has a lot of focus and design considerations because this screen is most frequently used. We have updated the calendar screen phase by phase according to the analysis of user feedback. At the beginning of the implementation the calendar screen was very simple and showing fertile window with its color.

In the second version of design we associated data to the calendar cells. We showed Monitor, Secondary LH, Mucus and Intercourse values with small graphical images on each cell. Associating graphical images helped users a lot. Application users no longer need to tap on any cell to view the associated data. However this presentation system is complex for general users. Finding a lot of image indicators makes them confused and they were unable get the clear picture of the data they have entered.

4.6 Handling Fertility Notifications

There are several special situations in which data entered for a menstrual cycle might indicate a condition or menstrual cycle variability that they need to consult with a professional nurse or primary care physician. We have handled the following conditions in the application:

- Short Cycle & Long Cycle: This kind of conditions can only be identified when a cycle is complete. Usually a cycle length varies from 22 to 42 days. If any couple are having cycle length shorter or longer than usual length we consider it as a special condition

- Unusual Uterine Bleeding: In a menstrual cycle bleeding (i.e., menses) occurs in the first three to seven days, Any bleeding after 7 days is consider as unusual bleeding. The user is notified with a message if they are having unusual bleeding. It is especially important to indicate unusual bleeding inside the estimated fertile window. We indicate bleeding in a fertile window with red borders. The deepness color shade of red border indicates level of bleeding.

4.7 Database and Controllers

As we are using phone based application we saved all data in a local database. We have used SQLite database engine. All database operations are done using MVC technique to keep functional logic and data access operations separate. To make the application version for iPad or even an online data sync option it will not require too much further development. When the calendar screen appears the controller requests a database for updated data and refreshes the screen with new data. The parameters which

are related to the entire cycle are called cycle parameter. There are four cycle parameters which are significantly important for any cycle. These parameters are:

- StartFertileWindow: the first day when a woman is fertile in a cycle

- EndFertileWindow: last day when a woman is fertile in a cycle

- EarliestPeak: the cycle day when first Peak

  (Monitor/SecondLH/Mucus/Advanced Digital Monitor) occurs

- LatestPeak: the cycle day when last Peak occurs

Calculating cycle parameters is the most important part of the entire application because it actually determines whether a woman is fertile or not for the current day. When any change made in the data entry screen all the cycle parameters are updated.

CHAPTER 5: EVALUATION

The Marquette Model of NFP provides the user an option of monitoring fertitly with a combination of a hormonal based electronic fertility monitor, cervical mucus based monitoring and/or basal body temperature monitoring. It was a challenge to combine the functionality of all these fertility monitoring methods and at the same time making it simple for any user who doesn't have knowledge of NFP.

It is important that user gets a clear view of menstrual cycle length, the start of the estimated fertile window and the end of the fertile window. We have calculated the start and end of the fertile window when any data is changed. In the calendar screen we have colored the entire fertile window with dark blue color; it distinguishes the fertile window clearly from pre-ovulation and post-ovulation period. Another purpose of the calendar screen is to provide a clear indication of the hormone status. Rather than showing each of the vital sign parameters separately, the system automatically combines values from the electronic fertility Monitor, the Secondary LH, Cervical Mucus and the Advanced Digital Monitor and provides a simple representation of day to day fertility status.

5.1 Different Features

The development approach for muFertility app followed experience and feedback from several experts and users to help increase menstrual cycle accuracy and a satisfactory user experience. It also uses emotion based user interface design. This makes the muFertility unique compared to the existing research based fertility applications. A simple but effective navigation system for the application is an important issue to make

users comfortable. We used a navigation controller to make the navigation system simple and quicker.

5.1.1 Background Research

This application follows the well researched and evidence based Marquette Model which has research evidence for its effectiveness, efficiency and accuracy.

5.1.2 Feedback Cycle Based Development

We have followed the agile method for development. The end users are the population who can contribute the best feedback for user experience. We provided the application to end users for 12weeks and modified the application with user requests. This makes the application more acceptable. We have also collected feedback from a physician and advanced practice professional nurses which ensure the effectiveness of the design from health specialist's perspectives.

5.1.3 Home and Calendar Screen Together

The application has both single screen based view and calendar based detail view. Users can use the application at the same time for quick data entry and detail analysis. Supporting both design concepts in a single application increases user satisfaction.

5.1.4 Simplicity

We kept presentation layers simple compared to the provided functional feature we have in the application. To provide the simplicity in the application we have introduced a unique method combining fertility indicator data for fertility phase

calculations. The combined parameter ensures the use of multiple fertility indicators and valuation of all parameters together.

5.1.5 Completeness

A keen question to our test users was "Does the application fill its need?" To answer this question we have collected a good number of new features request and feature enhancements for every iteration of the fertility application. At this stage of development we were able to meet the testers' requests successfully. However, there still are functionalities that were requested that need to be added. One of the most commons request is to have internet based data synchronization which ensures data safety. The following table demonstrates how new user requests were solved at every release of the fertility application:

Release Version	No. of functional issues	No. of design issues	New functional feature	New design feature
1-4	4	18	2	8
5-8	7	5	4	4
9-12	3	4	1	1
2	2	1	0	0

Table 5.1: Release issues

5.1.6 Focusing on User

The most common users of the application are couples (especially women). To be more specific most the targeted users for the application are women over 22. We designed the application theme and controls (buttons and other action inputs) considering it as a priority. We provided softer contrast, well oriented controls, and buttons with pictures so that the user interfaces match with user emotion.

CHAPTER 6: CONCLUSIONS

The muFertility application is published in the Appstore and we are hoping that it will be used not only all over US but also all over the world. The purpose of the application was not only to provide a usable application for NFP but it also spreads the knowledge and awareness to its users. Another purpose of the application is to bring the confidence at social level that NFP is the best way for Family Planning. In a broader sense NFP is the method that increases the understanding between men and women.

6.1 Summary

In this thesis we have presented muFertiliy application which brings the Smartphone technology to provide NFP for couples. We have started our development following the Marquette Method of NFP using general HCI considerations. Though the development process we have improved the application design from user feedback. The modified application is able to satisfy its current users. The next step from the NFP model perspective is to analysis user feedback and calculated data to improve the accuracy and efficiency of the application.

6.2 Contributions

The main focus of the muFertility app was to build an application that is able to provide NFP functionalities to aid couples to avoid or achieve pregnancy. At the end of development this application is able to provide the implementation of the Marquette Model in a hand held smart phone type device. It is also capable of handling the variability and special cases like short or long cycles and unusual bleeding etc. With a user feedback based design we are also able to identify some major UI design

considerations that get priority from the user perspective. This is the only application that follows Marquette Model of NFP and combines hormonal monitoring, basal body temperature monitoring and cervical mucus based monitoring in single application.

6.3 Impact

Though this application is focused on NFP and follows the Marquette Model of NFP, but we are able to bring contributions that can be followed for any mHealth application that requires daily data entry. The application is predicted to satisfy couples who are searching for a simple and reliable application for NFP. The application also integrated with basic NFP knowledge; therefore the application has the potential to spread the NFP knowledge not only to the couples who are interested to NFP but also the couples who are searching for learning more about NFP.

The application design reflects the user satisfaction because its presentation layer has a big contribution from end user feedback. In a broader context the design methodology brings the new mHealth application development strategy that promises to keep satisfying user expectation.

6.4 Future Work

The Marquette University College of Nursing Institute for Natural Family Planning already has an online charting method. In the future we are planning to create a new iPhone application which will have the same methods and user interfaces but additionally it will be able to synchronize all data to the server. This online system will have all data save to a cloud based system so that a user can login from anywhere and use any device to access their data. Also data for the users will not be lost if they lose their

mobile device. There are four level of application functionality is predicted for future work. In this thesis we have only discussed about the basic version. The next level will be data synchronization with online system. The third level of the application can be integrated with consultancy with NFP experts, physician and nurses it can also have alert system for fertility notifications. Additionally to provide proper support, next level will be having social networking system where app users will be able to share their calendar or current status.

The data from online system will also be a good source for research and analysis to increase the efficacy in avoiding or achieving pregnancy with Marquette Model. Another future work with the current system can be a SMS based version that can be used for Title X users of proposed government funded free phone. The complete NFP app system will not only be a perfect tool for NFP users but also be a part of spreading the knowledge and interest in use of NFP to couples who are not yet using NFP for their family planning needs.

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