Menstrual Tracking Support Technology

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Creative Technology

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Abstract

The aim of this thesis is to develop a menstrual cycle support technology that is able to help and guide first time menstruators through their first couple of years of menstruating. To know the characteristics and needs of the target group, online surveys are sent to women above the age of 18 so they can reflect on their own first two years of menstruation. After this, a brainstorm was conducted of all possible functions a period tracking app can have, and with the MoSCoW method the most useful functions were selected based on the results of the online survey. After the application has been fully developed, the user evaluation process was started where seven women tested the application and gave their feedback based on their experience using it. With all of the information gathered from the different chapters of the thesis, the research questions that were introduced in the first chapter were answered in the conclusion together with a look into what future research might look like.

The online survey showed that especially during the first two years of the participant's menstruation their period was incredibly unregular, meaning that they were not prepared most of the time. They mentioned that a period tracker app should clearly state to the user when their next period will arrive, together with a nicely designed calendar that visualizes this. Next to prediction, participants also mentioned that there were many menstrual-related subjects they were uneducated about during their first two years of menstruation and that they would have liked to have been informed about these subjects during this period of time. Based on these findings, the application went into development and seven women agreed to do an user evaluation to see if the product actually works as a well-developed menstrual tracking app for first time menstruators.

The results of the user evaluation showed promising results, with most participants stating that the application is well-designed and appropriate for the target group. The participants also mentioned some feedback points about some functions that could be added.

Table of Contents

List of Figures

Chapter 1 – Introduction

Only in recent years has menstruation gotten a fair share of attention within the research. Menstrual disorders have been around since the beginning of time but are only now being researched field (Jukic, 2020). During the menstrual cycle, the body goes through stages in which hormones are taking over the body and are responsible for physiological changes which are noticeable for the women themselves (Owen, 1975). Period trackers are popularly used by women to track and predict their next period. Period tracking can be done by monitoring physiological changes in the body, like calculating the basal body temperature or heart rate (Alzueta et al., 2022).

Menstrual tracking apps either use only user input, where the user manually fills in when they started and stopped menstruating, or with physiological data obtained by a wearable. There are already many period trackers that use sensors to track the user's menstrual cycle. Physiological data like basal body temperature or heart rate can be used to determine what menstrual phase the user is in with higher accuracy than applications that only use user input.

Since every menstrual cycle is unique, prediction can be extremely difficult and prone to error. Since hardly any apps exist that are able to be paired with a wearable, there is even a smaller category available for women who only just started menstruating. A highly accurate menstrual tracking app can be extremely useful for this target group since their body is going through many changes and personalised advice could help them tremendously. For example, a high iron drop is often seen when the woman is losing a great deal of blood during the beginning of their period, yet no products have been made yet to see observe this and notify the user so they are aware of their lack of iron. Low iron can result in fainting, which young menstruators might not realise is because of their period blood loss. This is why there is a need for a research into getting a more accurate reading of the entire menstrual cycle that is not only focused on notifying the user on ovulation time, but also on advising them how to deal with other physiological quirks that come with certain phases, like fluctuation in iron levels and communicating this in a way that is highly appropriate for the target group: first time menstruators (Leverton & Roberts, 1937) (Kim et al., 1993).

To be able to make an innovative product that is able to sense the menstrual cycle while also visualizing it in an appropriate way that speaks to the target group, there has to be some literature research done beforehand to see what technology already exists and which areas have room for innovation. The following question have to be answered:

How can apps and wearables assist young menstruators in understanding and coping with their menstrual cycles?

1. *What are the common challenges faced by young menstruators when it comes to understanding and coping with their menstrual cycles?*
2. *What features can be incorporated into apps and wearables to enhance young menstruators' understanding of their menstrual cycles?*

An extensive literature research can answer these questions, so in the upcoming chapters the stated research questions will be discussed and afterwards answered.

Chapter 2 – Background Research

2.1 Literature research

To get a better understanding of what the current status of menstrual apps and wearables is at the moment, a literature research and state of the art analysis will be conducted in this chapter.

Starting very basic, it is important to know how the menstrual cycle looks like. On average, the entire cycle lasts twenty-eight days. The first day of the cycle is also the first day of the period. On average, the ovulation is at the middle of the cycle, around day fourteen. The cycle ends when the first day of the next period begins. Since this information is based on an average, the actual cycle of a women can vary per person and also per cycle, especially during the first two years after the first period has started (Hawkins & Matzuk, 2008). Women typically begin menstruating at the age of 12, but this varies per person (NHS).

The menstrual cycle consists of four phases, the menstruation, follicular phase, ovulation and the luteal phase, as seen in figure 1. The menstruation is when the uterus lining flows out of the vagina. This phase has an average length of three to seven days. The follicular phase contains the menstruation and ends at the start of the ovulation. During this phase the body releases a hormone to stimulate the production of follicles on the ovary. After the follicular phase the ovulation takes place, which generally lasts somewhere from sixteen to thirty-two hours. During ovulation the egg is released from the ovary. The biggest chance of conceiving is three days before the ovulation and during the ovulation itself. After this phase the luteal phase begins, in which the body is starting to thicken the lining of the uterus to prepare for pregnancy. If pregnancy does not occur, the uterus lining will shed and thus a new period begins, as well as the next menstrual cycle (Better Health Channel, 2012).

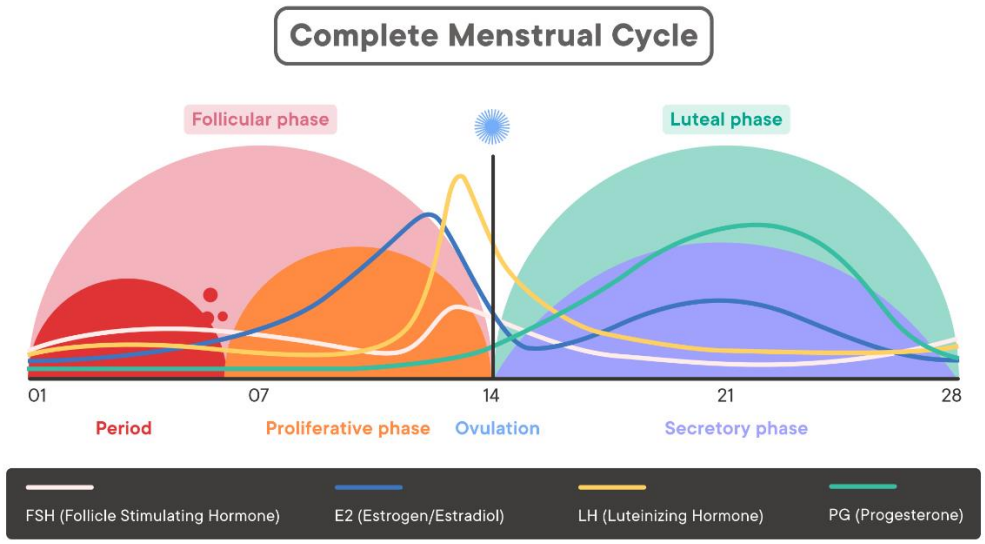


Figure 1 Menstrual cycle, illustration by Marta Pucci

The measuring of the Basal Body Temperature (BBT) is the most used method of determining which phase of her menstrual cycle the women is in. The Basal Body Temperature is the lowest body temperature that is recorded during the users sleep (Luo et al., 2020). The BBT changes throughout

the menstrual cycle and thus follows a periodic pattern that can be measured with temperature sensors. During the follicular phase the BBT is significantly the lowest while being the highest during the luteal phase. The rise of temperature occurs during the ovulation, which can be seen in figure 2 (Clue, 2017).

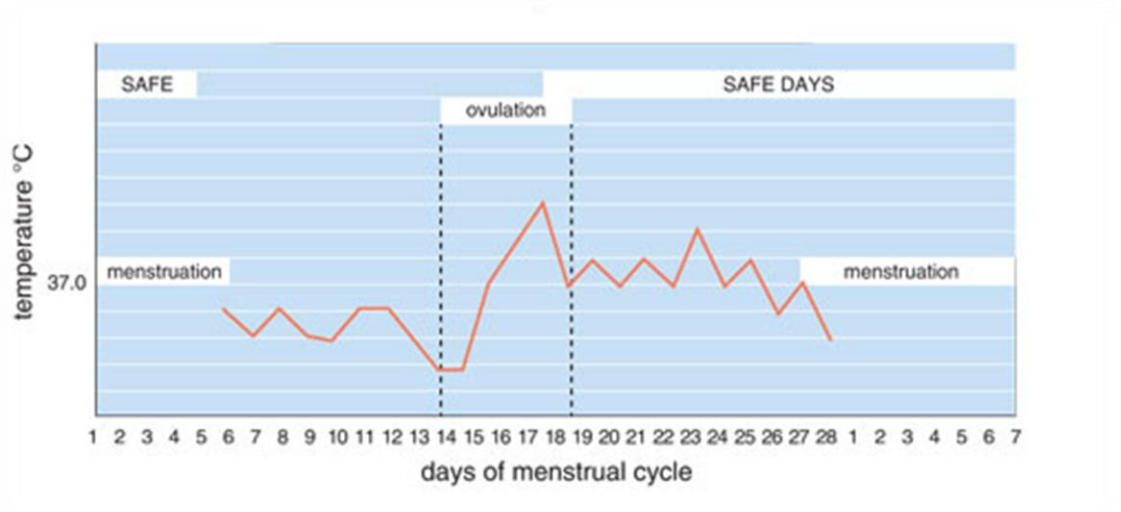


Figure 2 BBT through menstrual cycle, taken from OpenLearn create

The resting pulse rate also fluctuates through the menstrual cycle. The heart rate increases slightly during the ovulation and first week of the luteal phase. During the follicular phase the HR decreases. Next to HR, the heart rate variability also differs per phase. During the follicular phase the HRV is the highest, while decreasing during the luteal phase (Sims, 2022).

Figure 3 HRV during menstrual cycle, taken from HRV4Training

The breathing rate or respiratory rate also tends to vary over time. During the follicular phase and ovulation the RR decreases, while it increases during the luteal phase, which can be seen in figure 4 (Kryder, 2020)(Cleveland Clinic Medical, 2022).

Figure 4 Physiological changes through the menstrual cycle, taken from Oura.com test

While the previously mentioned physiological changes are already quite intricately researched, there are multiple studies that found slightly different results. The difference in results can be pinpointed to the details of the study, the amount of participants or the type of sensor that was used. Looking further into the changes in resting pulse rate, a study shows that the minimum average RPR is 55.5 beats per minute during the follicular phase while the maximum is found in the luteal phase with 59.3 beats per minute. This study also looked into the body temperature measured at the wrist, which has a minimum of 34.3 Celsius during the follicular phase and a maximum of 34.7 Celsius during the luteal phase (Stein et al., 2016).

Another study (Zhu et al., 2021) has focussed on measuring the body temperature at the wrist. This study has shown that wrist skin temperature that is continuously measured during sleep is more sensitive than BBT for the detection of ovulation. This is because there is a larger increase in temperature during the postovulatory phase and a bigger decrease of temperature during the menstrual phase for wrist skin temperature.

A study done by J. Yu was to find a better and more accurate way to depict menstruation and the fertile window by using more than only BBT. Yu found that using an algorithm that uses BBT and HR outperforms an algorithm that only used BBT by far. Not only in terms of accuracy but also in sensitivity and specificity. This research also confirmed that there is an increase in HR after ovulation (Yu et al., 2022).

Another study also found that HR increased during certain menstrual phase and so does the distal skin temperature. DST is the temperature of the skin that is located at a location that is further away from the center of the body, like the hands of feet (Liao et al., 2005). During the luteal phase of the

menstrual cycle the RV apparently is lower and the distal skin temperature drops around the ovulation. This study also found that the sleep duration was shorter during the mid-luteal and late-luteal phases. (Alzueta et al., 2022).

From this literature research multiple variables can be deducted that indicate what stage of the menstrual cycle the user is in. Other researchers found differing results than more prominent research and some studies found that measuring BBT at the wrist gives more accurate data. In the next sub-chapter multiple existing products will be discussed that are already using these variables.

Variable	Description	Indicates
BBT	Basal Body Temperature, the lowest body temperature measured during sleep	Lowest in follicular phase, highest in luteal phase
HR	Heart Rate	Decreases in follicular phase , increases in ovulation and luteal phase
HRV	Heart Rate Variability	Highest in follicular phase
RR	Respitory Rate	Lower during ovulation and higher in the luteal
Sleep	Sleep duration	Reduced REM sleep during luteal phase

Figure 5 Summary of physiological changes

The research in this chapter shows the methods on how accurate wearable readings can result in highly accurate period prediction results based on the physiological changes the female body goes through. The next steps are to research in what ways this technology has already been used and how it can help the target user, young menstruating women.

2.2 Start of the art

As for the state of the art of menstrual app/wearables there are already quite some products on the market that use the period prediction technology mentioned in the previous chapter. This chapter will look further into how these product are designed and what they could offer for the target group.

The Crimson Wave

The first product that will be discussed is the Crimson Wave. This is a mirror that lights up in a specific colour corresponding to the menstrual stage the user is in at that moment, which can be seen in figure 6. The usage of live data helps the user understand and optimize their menstrual cycle within each day. This product uses BBT to indicate the menstrual phase through an armband that the user wears during their sleep. Although the Crimson wave is interesting for users who have irregular periods and want to understand them better, the product is not commercially available and is mostly used as an research project (Flemings et al., 2018).

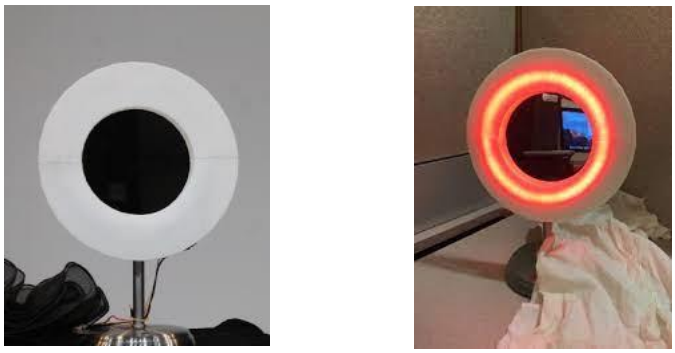


Figure 6 The Crimson Wave

The Oura ring

Another product is the Oura ring. This product uses BBT together with HR, HRV and nocturnal sleep to determine which stage of the menstrual cycle the user is in. This water-resistant wearable is worn around the finger like a ring that uses proprietary algorithms to process the data that it senses. Researchers have used the Oura ring for a study about the influence of the menstrual cycle on the changes in sleep. According to their research distal skin temperature, RHR and respiratory rate increased during their sleep while the heart rate variance decreased during the early luteal phase. The distal skin temperature is at its lowest around the ovulation (Alzueta et al., 2022).

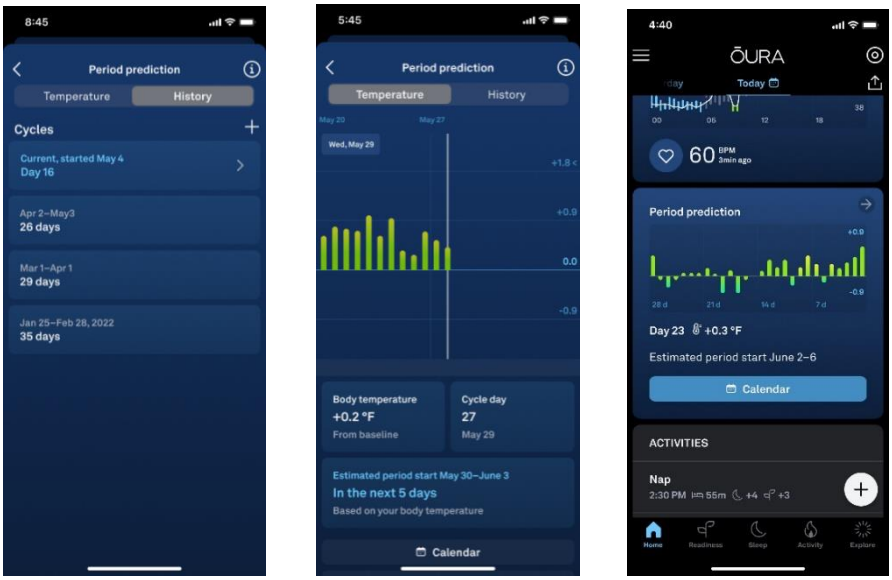


Figure 7 Screenshots of the Oura app

Ava Fertility

Ava Fertility is a tracking bracelet that is fully focussed on indicating the ovulation of its user. It notifies the user when they are most fertile so the chances of getting pregnant are the highest. The Ava bracelet uses pulse rate, breathing rate, sleep, heart rate variability and temperature to sense when the ovulation is happening. This data is then processed with machine-learned algorithms. The sensors that are present in the bracelet are temperature sensors, accelerometers (measurers sleep state and movement) and photoplethysmography (Captures heart rate variability, pulse rate, breathing rate, and skin perfusion) (Rothenbühler et al., 2019) (Shilaih et al., 2018).

Figure 8 Screenshots of the Ava Fertility app

Apple watch

The Apple Watch also has its own app that can track information about the menstrual cycle using heart rate data, BBT and user input. The app is also able to understand when there might be an indication of a medical condition. The usage of this app is mostly focussed when to expect a period, the fertile window and ovulation (Caddy, 2022) (Apple, 2019).

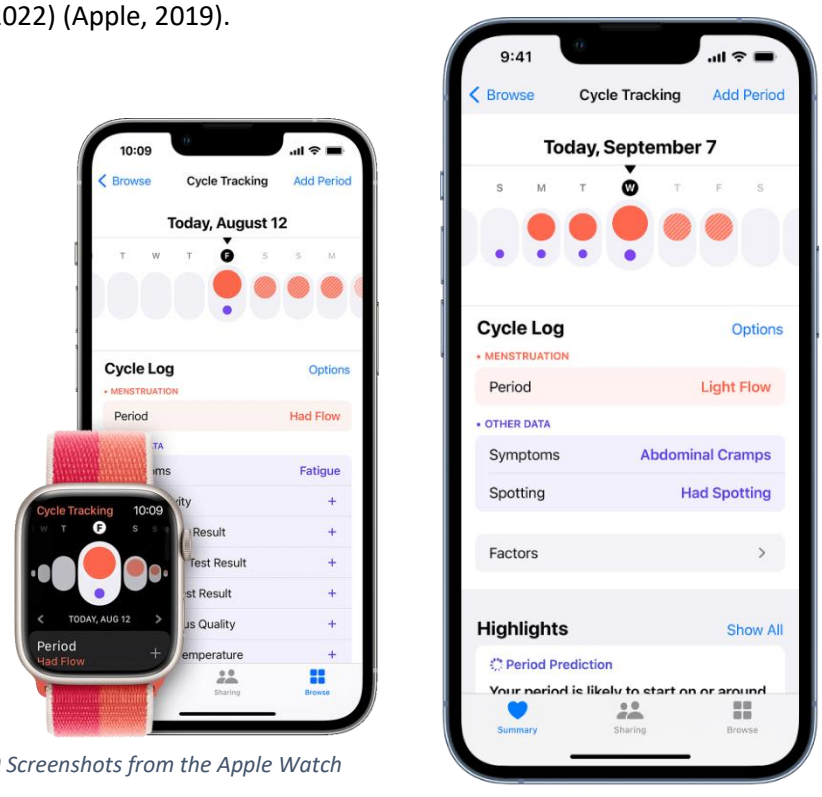


Figure 9 Screenshots from the Apple Watch app

Garmin

The Garmin Connect app includes a menstrual cycle tracking option. This product is mainly focussed on making choices based on health. The data is easily shared with the users GP. The app is able to support the user with information about nutrition and exercise during the different menstrual phases (garmin.com).

Figure 10 Interface of Garmin

Non-commercial products

Next to commercial products there are also products that are produced mainly for research purposes and are not ready to be sold to the general public. A study done on detecting the fertile window uses an in-ear thermometer. This product uses an statistical learning algorithm to detect and predict ovulation. The in-ear thermometer measures the temperature of the user while sleeping. This product also has a mobile application that visualises the data that it captures. The statistical learning algorithm that is used is the Hidden Markox Model (HMM). An algorithm like HMM allows for user-input to be incorporated and weigh into the processing of data. HMM is able to even provide accurate results for users with an irregular cycle (Luo et al., 2020). This study is just one example of menstruation tracking with algorithms but there are already more machine learning algorithms that can detect the fertile window with high accuracy (Goodale et al., 2019).

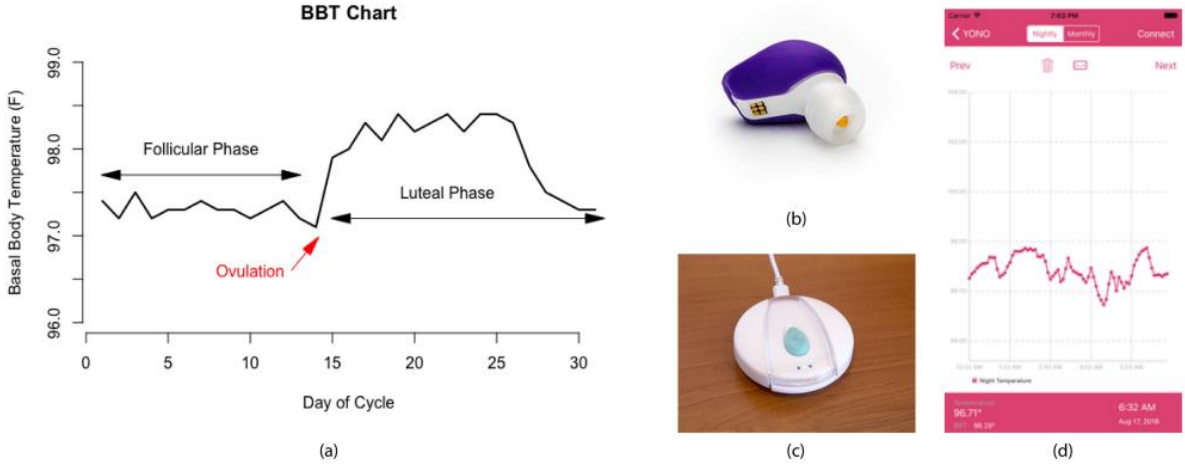


Figure 11 Ear thermometer and interface

Another example is a study done by K. Fukaya et al., where a statistical framework is provided that is able to predict the start of a menstruation based on a state-space model and a Bayesian filtering algorithm. Even though the length of a menstrual cycle naturally fluctuates, using filtering distribution that is updated daily can give accurate results of prediction of the day of onset (Fukaya et al., 2017).

Products for the target group

Taking a look at products that are designed for the target user group, first time menstruators, a few were found. The first product is the 'OKY' app, which completely focusses on young girls who are just starting their journey with menstruation. The app entails a calendar that tracks your menstruation cycle and also predicts when the next one comes. An encyclopaedia is also included with information about the menstrual cycle and a diary for the user to note their experiences in. This product only entails an app, so no wearable or measured data is used. This also affects the accuracy of the prediction of the next period, which can be faulty (*Oky Features*, 2020).

Figure 12 Screenshots of the OKY app

MagicGirl

Another example is 'MagicGirl', this app works similarly like the OKY app. It also contains a calendar that is able to predict their periods and is also able to provide videos, FAQ's and even a chat. Just like the OKY app, this product also does not use any measured data obtained from a wearable (*Magicgirl - Best Period Tracker for Teens and Tweens*, n.d.).

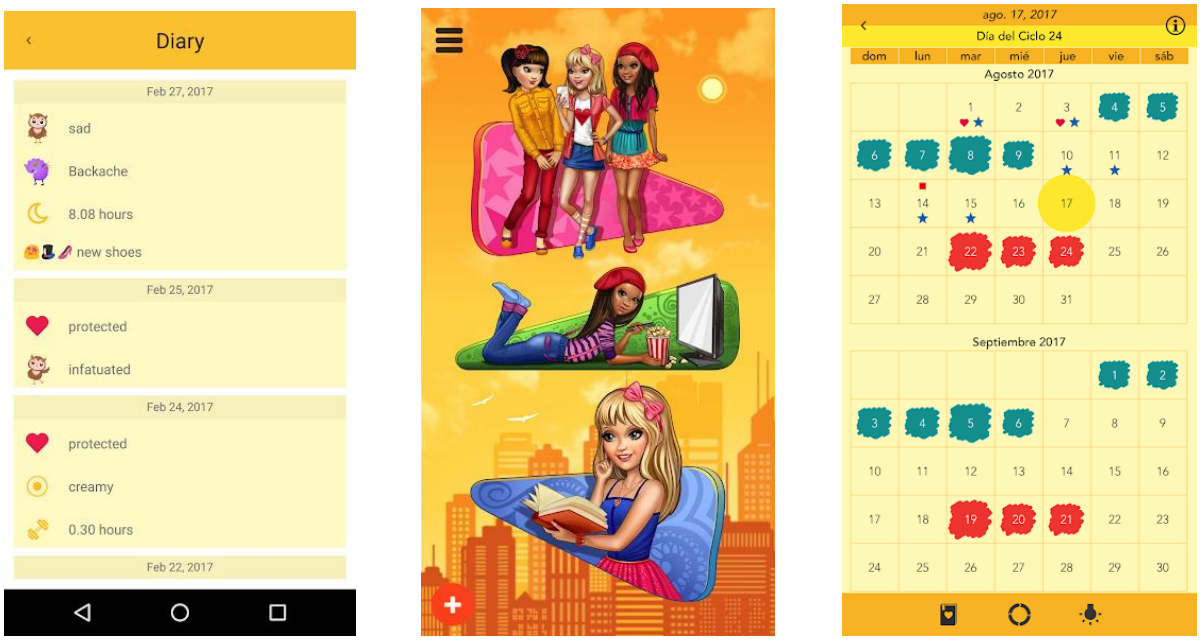


Figure 13 Screenshots of the MagicGirl app

2.3 Evaluation of the State of the Art

The information from both the literature research and the state of the art give great insight into the first research question. BBT, HR, heart rate variation and breathing rate are the parameters that are able to determine which menstrual phase the user is in. To get the best results, these parameters should all be considered and measured. In addition to these parameters, algorithms can be applied to the acquired data to optimize the data processing and get the most accurate conclusions.

Getting accurate data is one thing, the visualisation and usage of it in the app is another. The Oura ring only shows minimal graphs with hard data. The graph is quite small, and hard to understand. The Oura ring also only works on a standalone wearable, the Oura ring. It is a lot to ask of the user to spend €314,- on just the wearable alone, especially when the typical users are young women around the age of eleven.

The Ava Fertility app's interface is a bit more structured and user friendly. While the graphs display a lot of information about what the wearable is tracking, this information is not very interesting for young users since their bodies are already going through big changes, the graph of their breathing rate won't mean much to them. Ava Fertility, while also being able to give information about which menstrual phase the user is in, is mostly focussed predicting the fertile window. This is not interesting for first time menstruators and might even intimidate them. Just like the Oura ring, Ava Fertility only works on a standalone wearable, which in this case is a bracelet. A standalone wearable entails a too large threshold for a first time menstruator to buy, that is why the product of this thesis should be available on more widely available wearables, like a smart watch.

Showing the data clearly is important but teaching first time menstruators what problems each phase conduct is another challenge that the product has to tackle. The discussed products in the state of the art don't give any feedback on this, they only allow user input for e.g. how many cramps the user endured. That's why it is important that this is included in the design process of the product.

The product that are catered to the target audience already give insight into how the design decisions are affected if the interests of the target users are taken into account. From colours to user experience, the entire product will differ from products that are catered to a more 'mature' audience. Design-wise this might work as an advantage, but technology wise products like 'MagicGirl' fall behind the larger apps like 'Ava Fertility'. The target user appropriate apps do not work with any measured data obtained by a wearable worn by the user, hence the prediction of the period will also be less accurate.

In the table below all of the products are summarized into a table to get a better overview of what products are currently on the market.

Overview

Table 1 Overview State of The Art

Product	Sensors	Data/variables	Wearable	Usage	Visualisation
Crimson Wave	Biosensor	BBT	Armband	Stage of menstruation	Light of a lamp
Oura ring	Body temp, infrared, accelerometer, gyroscope	BBT, HR, HRV, nocturnal sleep	Ring	Stage of menstruation	App
Ava Fertility	Temperate, photoplethysmography, accelerometer	BBT, breathing rate, sleep, HR	Ava Bracelet	Fertile window	App
Apple	Temperature, heart rate	BBT, HR, user input	Apple watch (smartwatch)	Stage of menstruation	App
Garmin	Not disclosed	Not disclosed	Garmin (smartwatch)		Smartwatch
Ear thermometer	Body temperature	BBT and algorithm	Ear thermometer	Stage of menstruation (also for irregular cycles)	App
OKY	-	User input	-	Stage of menstruation	App
MagicGirl	-	User input	-	Stage of menstruation	App

Table 1 shows an overview of all the products and applications mentioned in this chapter.

This chapter has shown what products are already out there, and how they implement the menstrual prediction technology that was researched earlier in this thesis. The background research for a well-developed menstrual tracking app is done, but it isn't clear how appropriate these application are for the chosen target group, which is young menstruators. With the knowledge obtained by the this chapter the next steps of the thesis need to be planned out and brainstormed, which is what will happen in the next chapter.

Chapter 3 – Methods and Techniques

In this chapter the design process will be explained. With the information gathered from the previous chapter, it is now clear what steps need to be taken.

While there are already quite some products on the market that are tailored towards measuring the menstrual cycle, like the Oura ring or Ava Fertility, they all miss out on certain aspects to optimize their usage. Ava Fertility is as of now on top of the chain with regard to accuracy of their measured data, but their product is mostly targeted towards women who are hoping to conceive. Just like Ava Fertility, the remaining products that were discussed in the previous chapter are not made comfortably for first time users. Especially for women who are starting to menstruate there is a lot of shame felt around such a natural process (Davies et al., 2022). Products that are fully marketed for women who are trying to conceive might frighten girls who are only starting their way into womanhood. This is why the design process needs to focus on using the data and portraying it in a way to make it most accessible and comfortable for first time menstruators.

Stakeholder analysis

The users (first time menstruators)

- The users of the app are very important, they should be kept in mind in every decision that is made when designing the product.

Parents/legal guardians

- Since the typical user is under the age of eighteen, their parents/legal guardians need to be actively engaged and satisfied with the product. The parents want a safe app for their child to use and has to be made sure that the app has a positive influence on their child.

Investors

- Investors do not have a large interest in the specifics of the product but do hold some influence.

Data privacy regulators

- Data privacy regulators are interested in what type of data is managed in the product and how it is stored. They regulate the safety of this data and need to know exactly what happens with it.

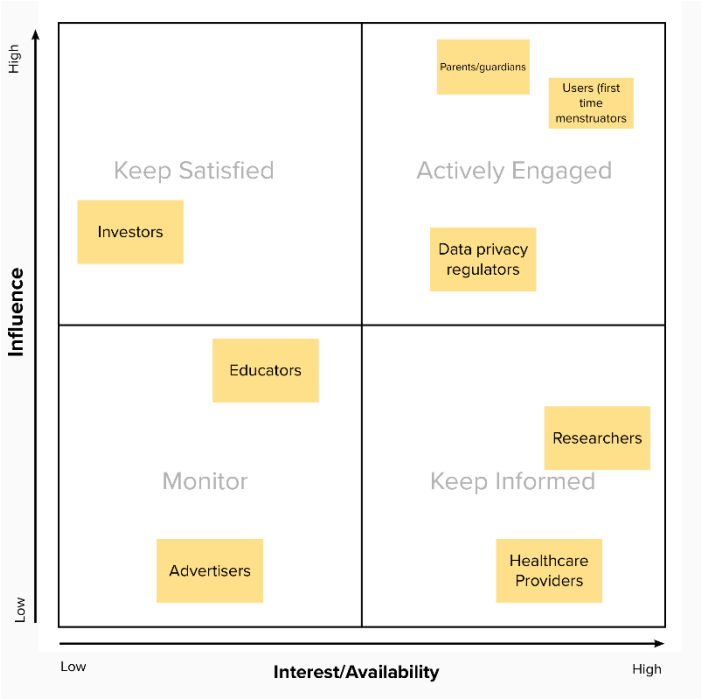


Figure 14 Stakeholder analysis

Educators

- Educators have some interest and a little influence on the product.

Researchers

- Researchers may have quite some interest in the product because of the amount of data that is acquired from the users.

Advertisers

- Advertisers hold little power but might be interested in what aspects of the app they could sell and advertise.

Healthcare providers

- Healthcare providers can use the app or promote the app if they are content with the product.

The stakeholder analysis shows who to take into account when designing the application and who's needs are most important. The target group needs are on the forefront to attain to, but since they are not of legal age yet the parents/legal guardians of the target group also need to be accounted for. This means that users most of the time need approval of their guardians to use/download apps.

Surveys

To get a better understanding of what the target group wants and needs, a survey was conducted to get a better understanding of what the product has to do to provide to its users. As seen in the stakeholder analysis, the users are one of the most important stakeholders, that's why their needs have to be closely monitored. Surveys are a good way to get a lot of quantitative information in a short amount of time. All of the interviewees will be over the age of eighteen, since interviewing or working with minors will be too ethically difficult for the scope of this project.

Design choices

The information of the survey will give insight into what design aspects are appropriate for the target group and what functionalities the application should have. A brainstorm will be held to collect all options of app functions, so that a selection can be made that is appropriate for this thesis' scope. Next to that a design needs to be chosen for the application itself, based on the survey's results.

Based on the results of the survey, it needs to be finalized what type of information will be included in the app, and how it will be presented to the user. One example of useful information for the target group is an iron drop that takes place around the menstruation because of the blood loss (World Health Organization, 2014). Symptoms of this type of iron deficiency include fatigue, dizziness, headaches and weakness (Health, 2020). These educational features need to integrated into the user experience and placed correctly in their accessory menstrual phase.

Moscow method

To start of the design process, the MoSCoW method can be applied to get a good understanding of what can or should be included in the product (Business, 2022). To be able to properly fill in the MoSCoW method it should be researched what the apps like Ava Fertility are already able to do, and also what is missing. The information of the surveys need to be processed and the highlights of the results can also be used for the MoSCoW method.

Once there is a clear list of the requirements of the product, there should be some decisions made on account of what is feasible for this thesis. The finalized list of requirements will be used for the user evaluation to see if the final product actually performs well enough to reach the pre-set goals.

Conclusions of the MoSCoW method will be used to get further into the ideation process, which will be discussed in the next chapter.

Chapter 4 - Ideation

The ideation chapter will start off with discussing the online survey and its' results, since this will set a base for all of the ideation choices.

In the previous chapter there were already some menstrual tracking apps mentioned. Some of these apps were designed for specific target groups, other weren't. Since every app has a different interface and look, an online survey is conducted with women over the age of eighteen to give their feedback on some of the already existing apps. The actual survey can be found in the Appendix 1.

The survey starts with some questions about the participants experience with menstruation. The questions regard what challenges they faced during their first two years of menstruation and how they dealt with it. After these questions, four interfaces of four different apps are presented to the participant and they are asked to give their opinion of the interface's aesthetic and design, and if they would have used it when they were first menstruating.

Sixty-three women, all above the age of eighteen have filled in the survey. The largest part of these women are twenty-one years old. Figure 15 shows the distribution of the participants age's, it doesn't contain all of the participants age's since some participants chose not to answer this question.

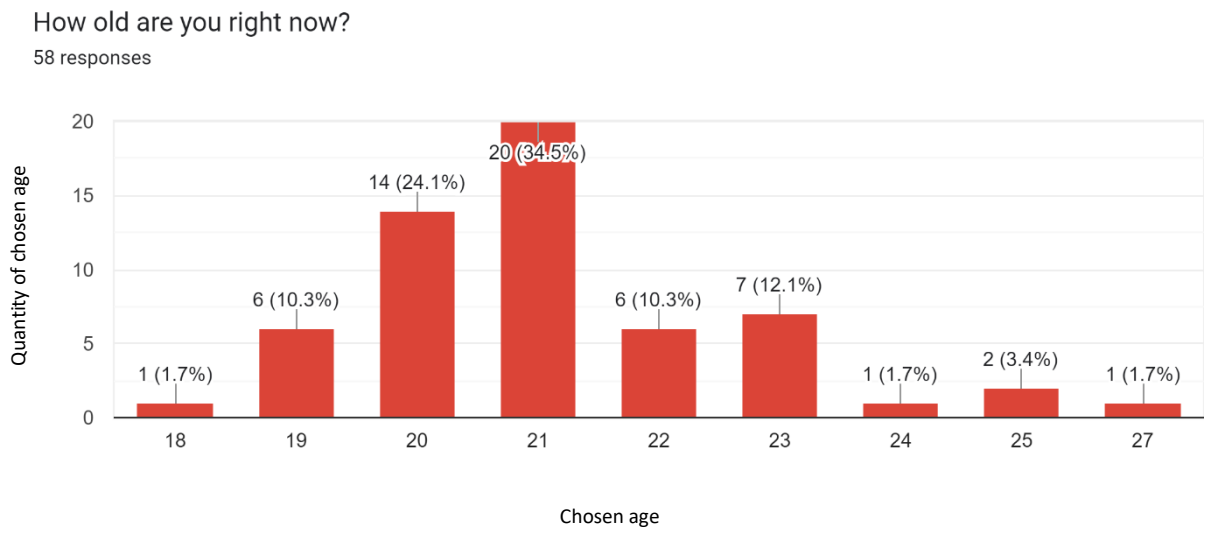


Figure 15 Age distribution of online survey participants

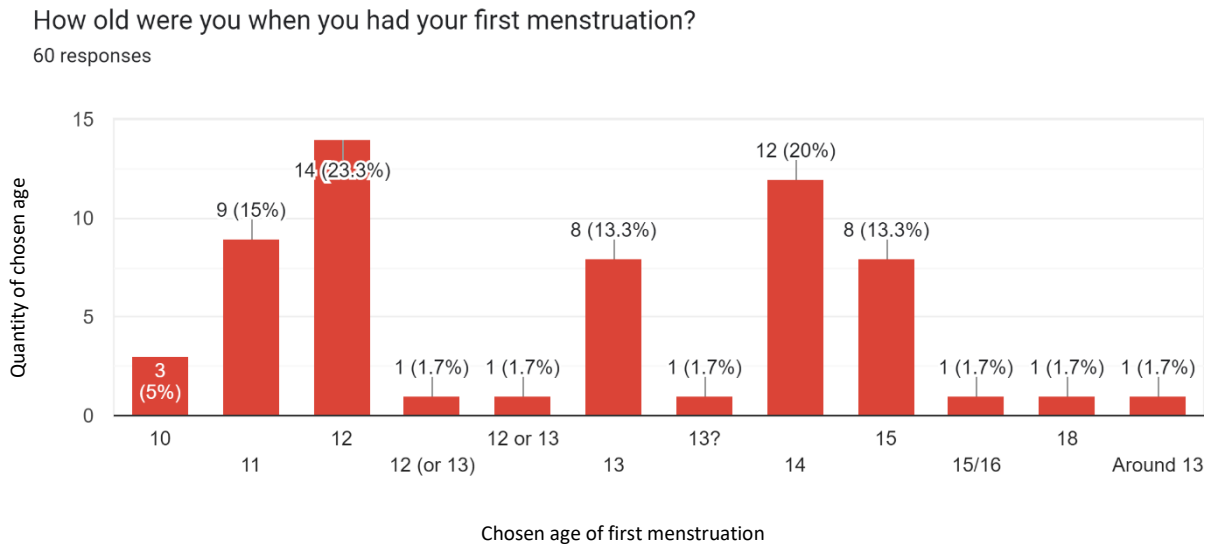


Figure 16 Age distribution of first menstruation

Figure 16 shows the age distribution of when the participants had their first period. This graph gives better insight to what age category the application has to be designed for.

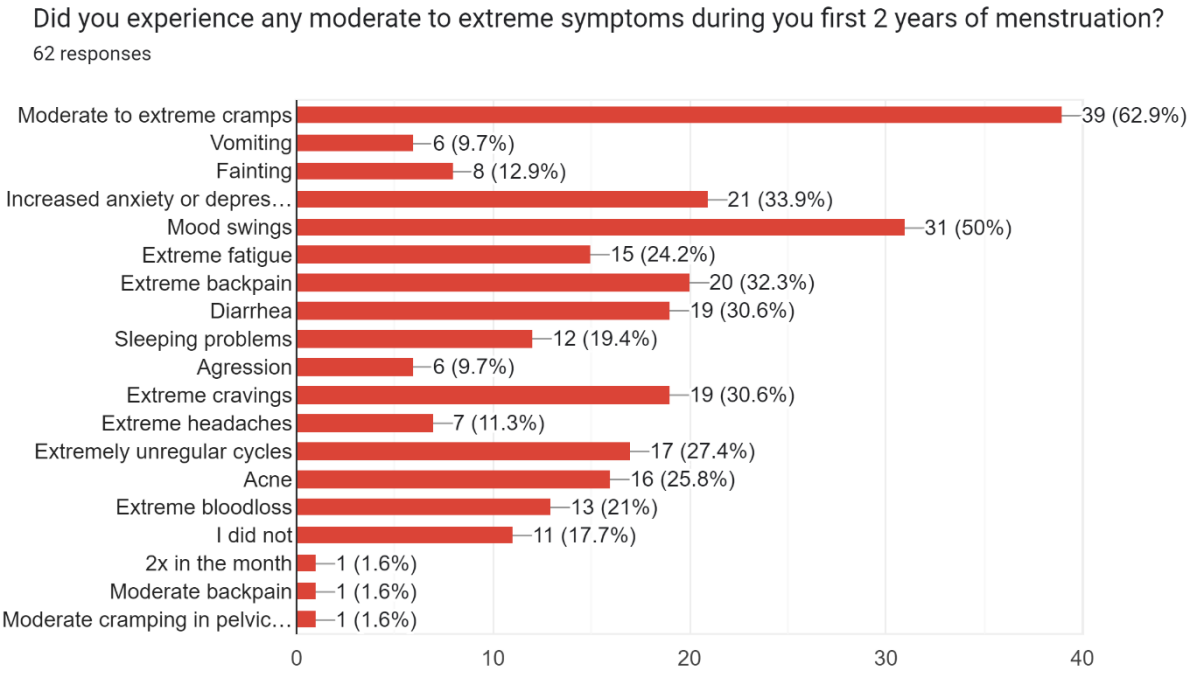


Figure 17 Answers to moderate-to-extreme symptoms during the first two years of menstruation

Figure 17 visualizes the symptoms that participants had during their first two years of menstruation. Remarkably, every participants seems to have experienced at least one moderate to extreme symptom during their first two years of menstruation, with 62.9% saying they experienced moderate to extreme cramps and half of the participants saying they experienced mood swings.

The follow up question for the previous question entailed the participant explaining when these symptoms started and if it interfered with their daily life. Thirty-four percent of participants who answered that they experience moderate to extreme period symptoms also said that it used to interfere with their day-to-day life in the first two years after they started menstruating.

A quote from one of the participants on how unregular her periods used to be:

"Yes because I would never know when my cycle would start. There was no point in registering it because it would be different every time. I would sometimes not have a period for two months and then have a period for 1.5 week followed by 3 days of nothing and another 1.5 week of having my period. I'd just wear pantyliners everyday just to be prepared in case I'd start bleeding. Also I always bled excessively especially on the second day (still have that) so I needed to go to the bathroom every hour or so to make sure that I wouldn't leave puddles of blood everywhere."

The survey also asked the participants how they felt around the subject of menstruation when they were younger. 53% of the participants said that they felt uncomfortable talking about the issue of menstruation, and some participants still do.

Quotes from some of the participants:

"It was very embarrassing, I didn't even feel comfortable enough to open a pad in a restroom."

"I thought I wasn't allowed to talk about it, and I was scared to research it. Sometimes I'd hear others talk about it so I'd listen in but not contribute to the conversation."

"I felt horrible. Everywhere I heard about menstruation being disgusting, so I felt quite disgusting at that time."

While not every participant felt this way about menstruation during their first two years, more than half did. It is important to take this into account when designing the application, because this means that some users might not feel comfortable with downloading an app that is very obviously a menstrual tracking app.

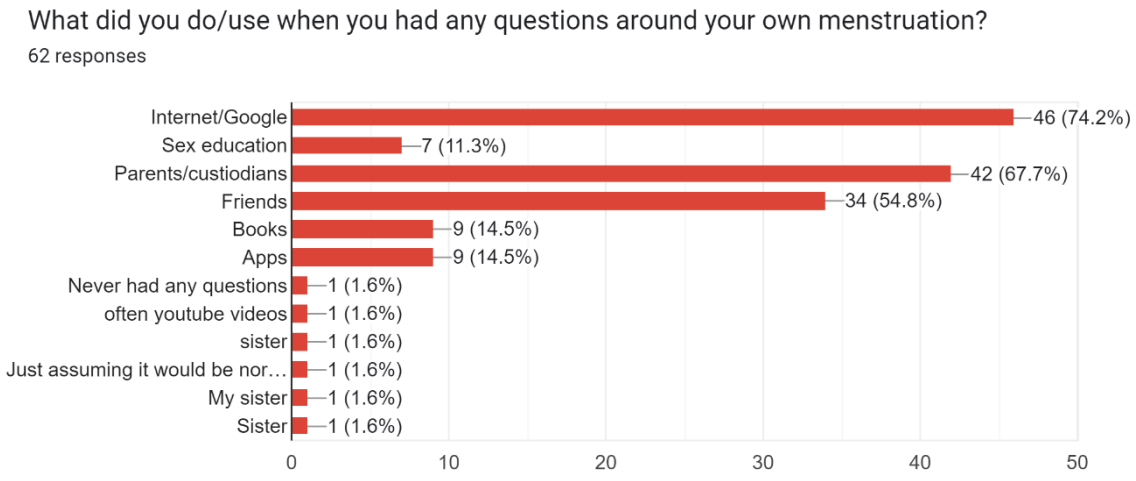


Figure 18 Answers to where participants got help for their menstrual questions

Graph 18 shows that 74.2% of participants used internet/Google for information when they had questions regarding their menstruation.

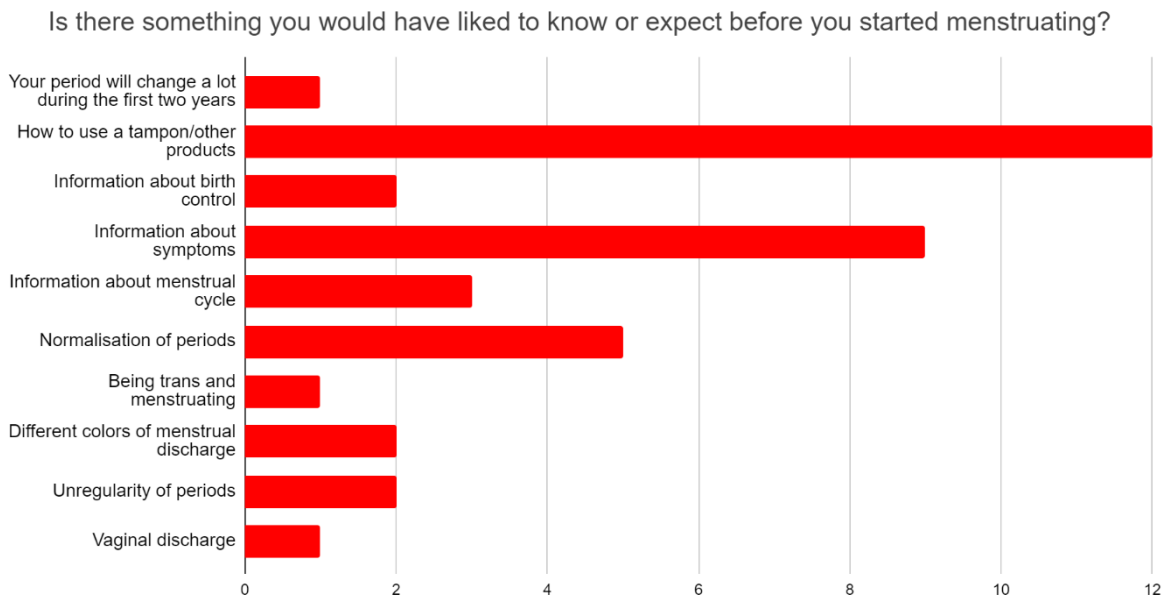


Figure 19 What the participants would have wanted to know before their menstruation

In graph 19 the answers are shown on what participants would have liked to know or expect before they started menstruating. 33,3% of answers said that the participant would have liked information about how to use a tampon, or even general information about what period products are out there and if there are environmentally friendly options. A quarter of the answer mentioned that they would have liked more information about what symptoms they might experience during their menstrual cycle and how to deal with it.

One participant mentioned that they would've liked more advice on how to deal with menstruating for women who are transgenders (going from female to male).

13.8% mentioned that they would've liked to have more confirmation that periods are normal to have and that they don't have to be ashamed of it.

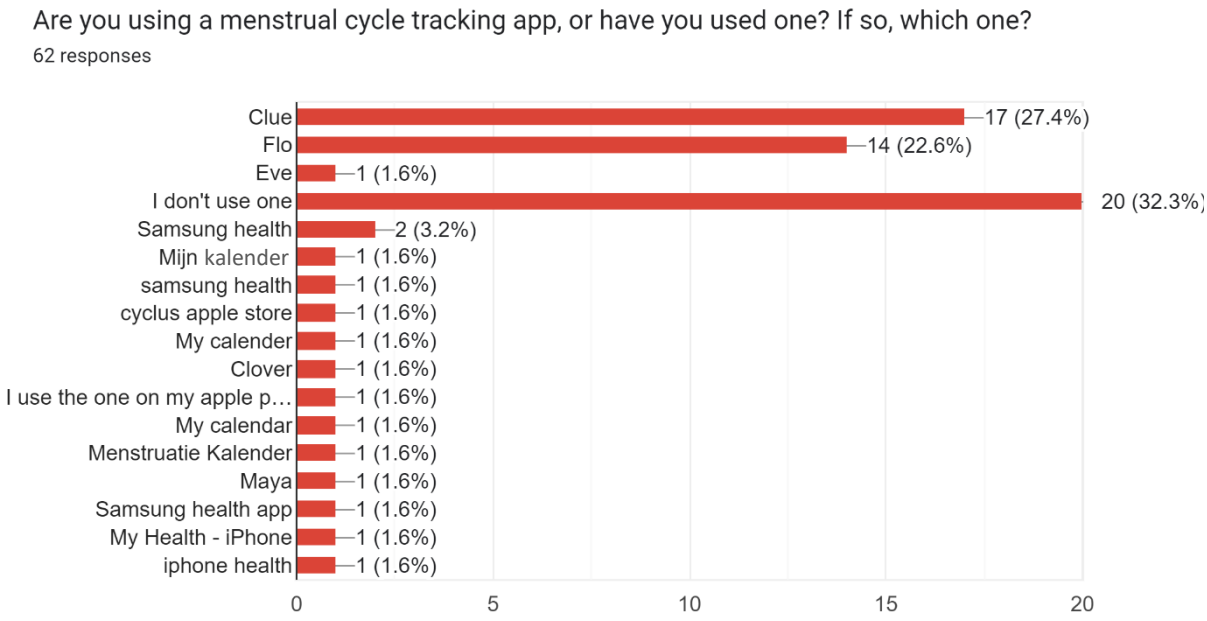


Figure 20 Distribution of usage menstrual tracking apps

67.7% of the participants have used a menstrual cycle tracking app before, with Clue coming out as the most used, with Flo coming up as second most used.

The second part of the survey shows four interfaces of already existing menstrual tracking apps. The participant is asked to give their opinion on the interfaces' colours, functionalities, aesthetic, name and design.

The first interface that is shown to the participants is the interface of the app 'MagicGirl'. This application is designed specifically for the target group of this thesis.

Table 2 Overview feedback on MagicGirl

MagicGirl	
Pros	**Cons**
- Nice calendar - Name is not too obvious - Aesthetics - Colors - Easy and basic - Informal - Like a game - Easy to understand	- Name aesthetic demeaning - Looks like a game (too much color) - Too childish (colors and girls) - Colors are too busy - Girls look cringe - Too girly - Not very clear - Now low key - Too busy design - Name is not attractive - Too animated
Takeaways: - **Aesthetics is a personal preference, some really like the more childlike side of it, others hated it** - **They liked that it was quite basic and easy to understand**	

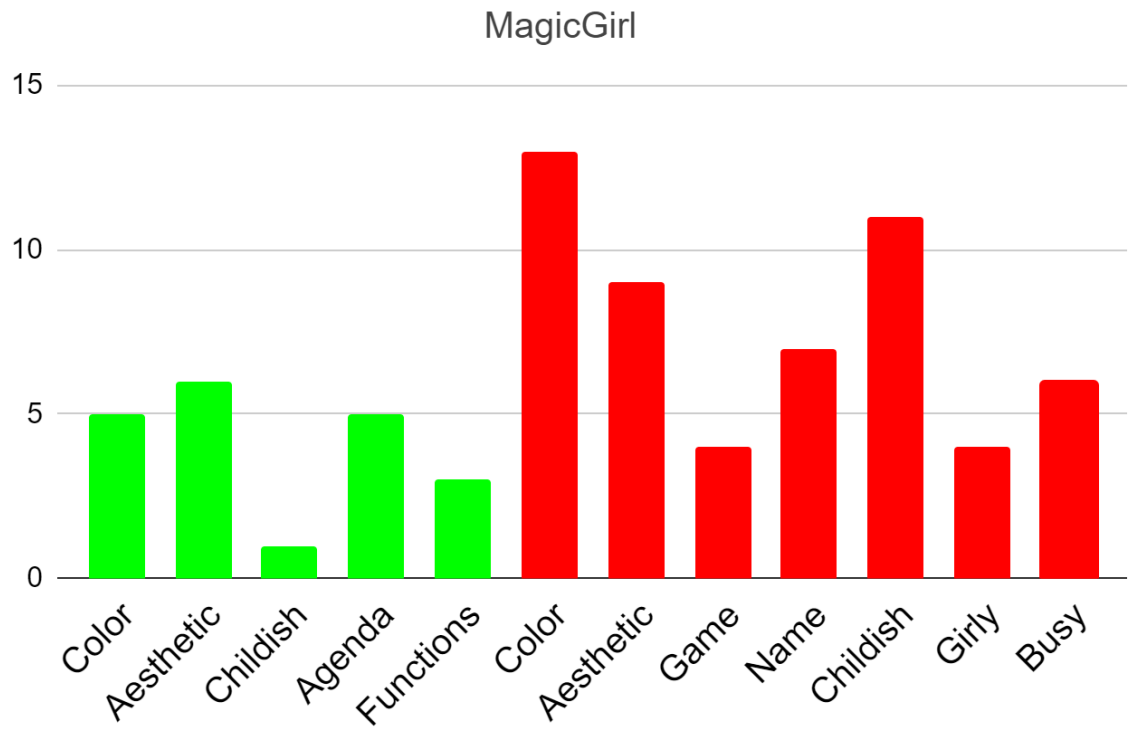


Figure 21 Quantity of words named in feedback for MagicGirl, red meaning negative feedback and green/blue meaning positive feedback.

In graph 21 it can be seen that the feedback that 'MagicGirl' got relatively more negative is than positive feedback from the participants. Most negative feedback regards the aesthetic and colour palette of the interface, with participants explaining that the bright colours made the interface look too crowded and too childish. The animated girls that are part of the first page of the app were also not popular amongst the participants, being deemed too childish.

The second interface is from 'Ava Fertility', which is also a menstrual tracking app with the target group on women who are trying to conceive.

Table 3 Overview feedback on Ava Fertility

Ava Fertility	
Pros	**Cons**
- Looks trustable - Appealing and calmer colors - Clear overview - colors	- Too professional - Too serious - Not suited for the needs of the target group - Too difficult - Don't need the features - Don't want to buy the watch - Too intrusive - The name - Intimidating - Not sure how to interpret all the graphs and data
Takeaways: - **Overall, the colors and layout were better received, since it looked calmer** - **The name was very of putting and the fact that it is catered to women who are trying to conceive** - **The graphs are too difficult and not necessary**	

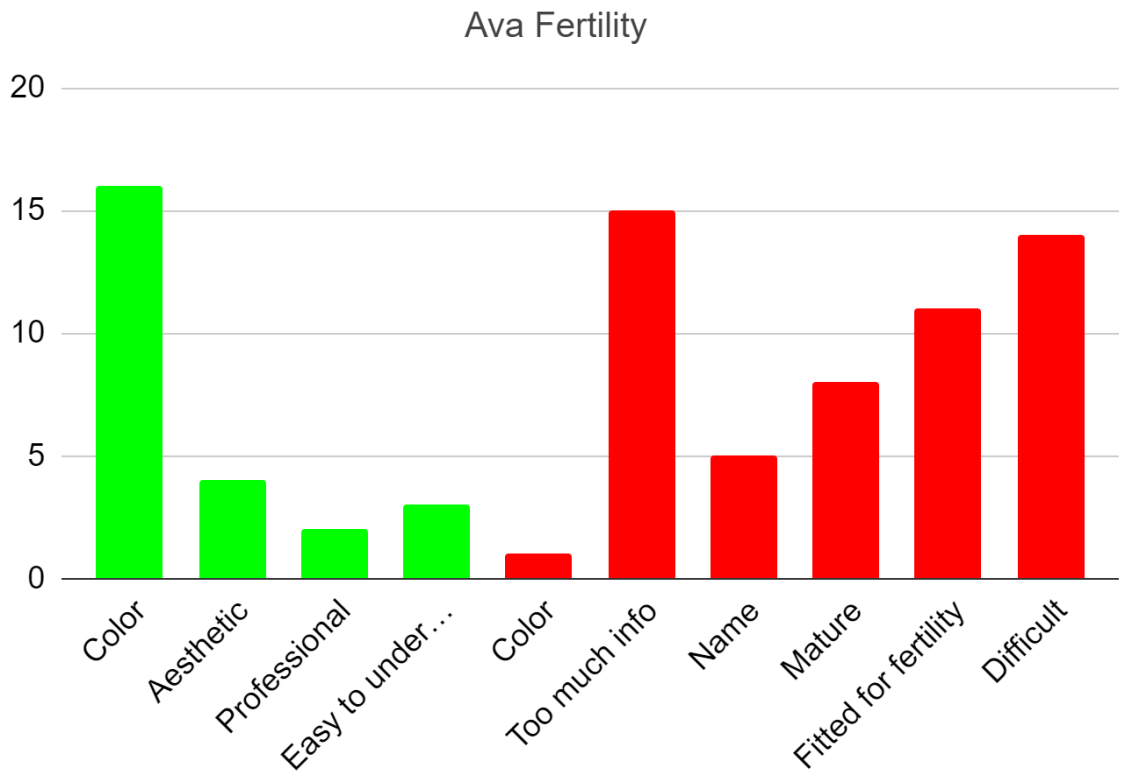


Figure 22 Quantity of words named in feedback for Ava Fertility, red meaning negative feedback and green/blue meaning positive feedback.

Ava Fertility got relatively better feedback regarding the design compared to 'MagicGirl', stating that the calmer colours looked appealing and calmer. However, the functionalities of the app got more criticism from the participants, stating that it too difficult and mature for the target audience of this thesis. Especially the graphs are unnecessary and difficult to understand. The redundant information won´t fit into the target user´s priorities and put them off of using the app. The fact that Ava Fertility is catered towards women who are trying to conceive, is also very off putting for the target user.

The third interface belongs to 'Oura'. This application is paired with a wearable ring and does not necessarily cater to a specific target group.

Table 4 Overview feedback on Oura

Oura	
Pros	**Cons**
- Clearly indicates when the period starts - More modern and trustable to simple and decent colors - Wants less of your data - Nice dark mode - Clear overview - Pane-based layout - Name - Nice functionalities	- Difficult - Too professional - Dark - Less feminine - Too boring - Too boyish - Too practical - The colors look sad - Name is not clear - Too much information - Looks manly
Takeaways:	

- **Oura was better received, but the app was found mainly too dark and mannish**
- **The information is more clear than ava**
- **Some liked that the name didn't have a connection to menstruation, others didn't**

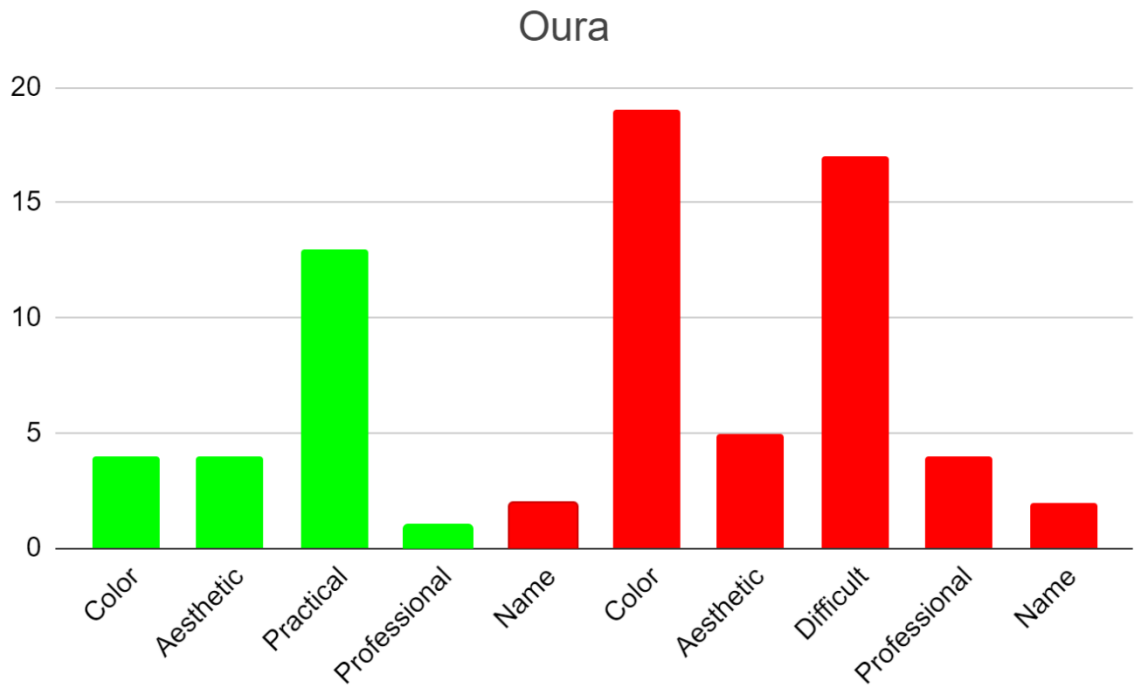


Figure 23 Quantity of words named in feedback for Oura, red meaning negative feedback and green/blue meaning positive feedback.

A couple of participants were excited about the dark theme of the Oura app, but the large part of participants weren´t. Many participants deemed the dark theme too masculine or boring. The interface is also too difficult to understand, especially for the target group, since it shows too much unnecessary information.

The last interface that was shown to the participants was the OKY app. This app is also specifically designed for young menstruators.

Table 5 Overview feedback on OKY

OKY	
Pros	**Cons**
- Clear and simple - Cute - Colorful - Like a game - Countdown - Clouds - Showcases important elements, how many days left of your period	- Too childish - Too much going on - Less clear overview
Takeaways: - **Oky got good results, it comes down mainly onto personal preferences of what people like (colors)**	

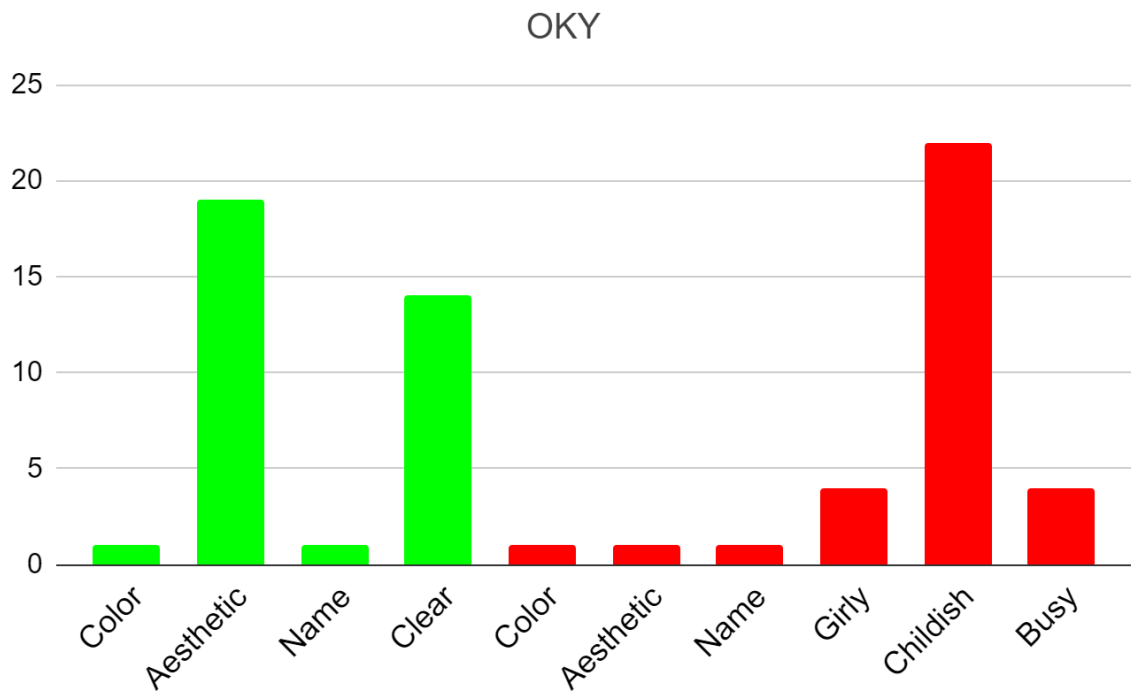


Figure 24 Quantity of words named in feedback for OKY, red meaning negative feedback and green/blue meaning positive feedback.

Compared to the other apps, OKY had some of the better feedback especially regarding the design. More participants liked the design and colours, while there was also a large part of participants who still deemed it as too childish. The interface did get seen as clear and easy to navigate.

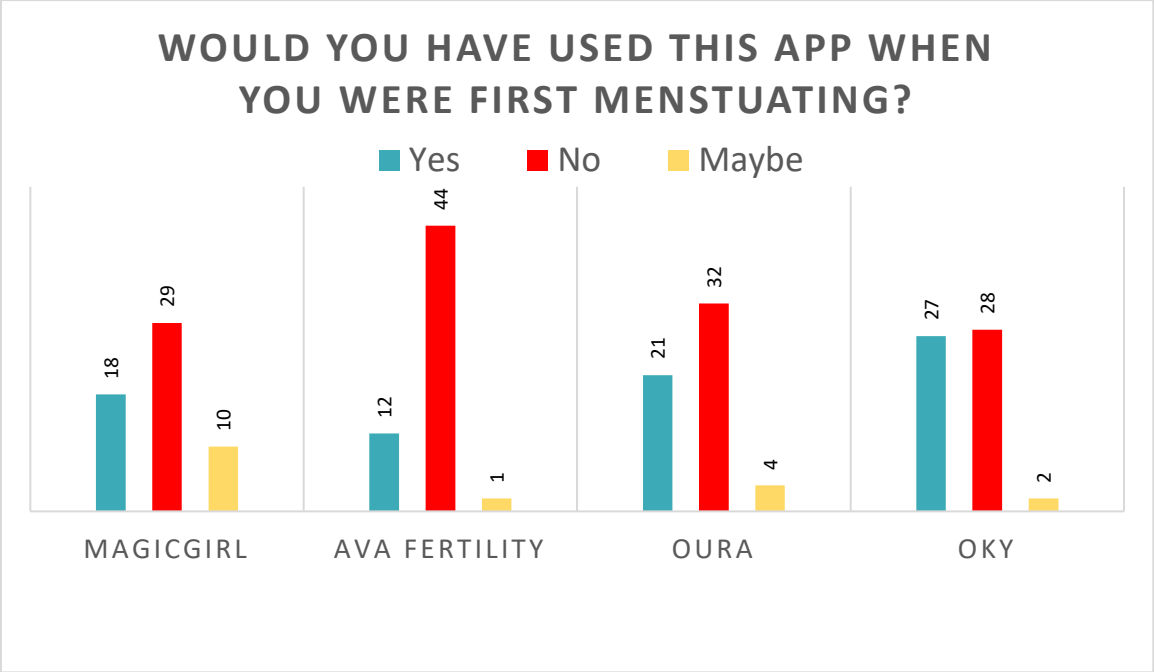


Figure 25 Results on if participants would have used the app when they were first menstruating

From figure 25 it can be concluded that the OKY app got the most votes from the survey meaning that most women would have chosen the OKY app when they were first menstruating. Ava Fertility scored the lowest, meaning that most women would not use this app when they were first menstruating.

The results of the survey give insight into the general mindset of a young menstruator, especially the results to the first half of the survey. The results show that the target group mainly wants a way to know when their next period is coming, since most of them deal with very unregular menstruations. Next to prediction, the target user also want to know what they can experience during their menstrual cycle with personalised advice on how to deal with it. This includes information on how to use tampons, but also the explanation of certain symptoms.

Functionality wise, apps that use intricate graphs might have a negative impact on the user experience since most young users won't care for these graphs nor even understand them. This is why the usage of graphs needs to be minimized in order for the application not to be deemed as too difficult. Too many functions will also confuse the user, and especially for the time scheme of this thesis, only the most important functionalities need to be incorporated.

Next to functionalities, the app also needs to be careful on how it will communicate information to the user since the target group is in a difficult transition from child to adolescent, whereas they wouldn't enjoy a very childish nor a very mature/professional language style. Especially the usage of difficult/medical language will only confuse the user, childish language will discredit the user and make them feel inferior.

The interface of the app might be the next most important issue. The biggest takeaways from the user surveys show how certain design choices have to be considered to fulfil the wishes of the target user. In the domain of layout design, the aesthetics should be light and clear. The biggest feedback points about the layout design were that it was either too girly or too professional. Too girly meant that the colours were to vibrant and the usage of girl characters made it feel too much like a game. The apps with darker colours were deemed to professional and not appropriate for the target group. The app that will be made for this thesis will need to have a light aesthetic with not too vibrant colours. Keeping in mind, the best aesthetic choices are subjective, and the choices that will ultimately be made are chosen so the largest group of users will be content.

In figure 26, an ideation mind map can be seen about all possible features and functions that could be implemented into the app. All possible features are collected from the state of the art. In table 7 a selection is presented with functions and features that seem most applicable for the target user. In the table itself the reasoning can be read on why certain features are chosen to be implemented and why some aren't.

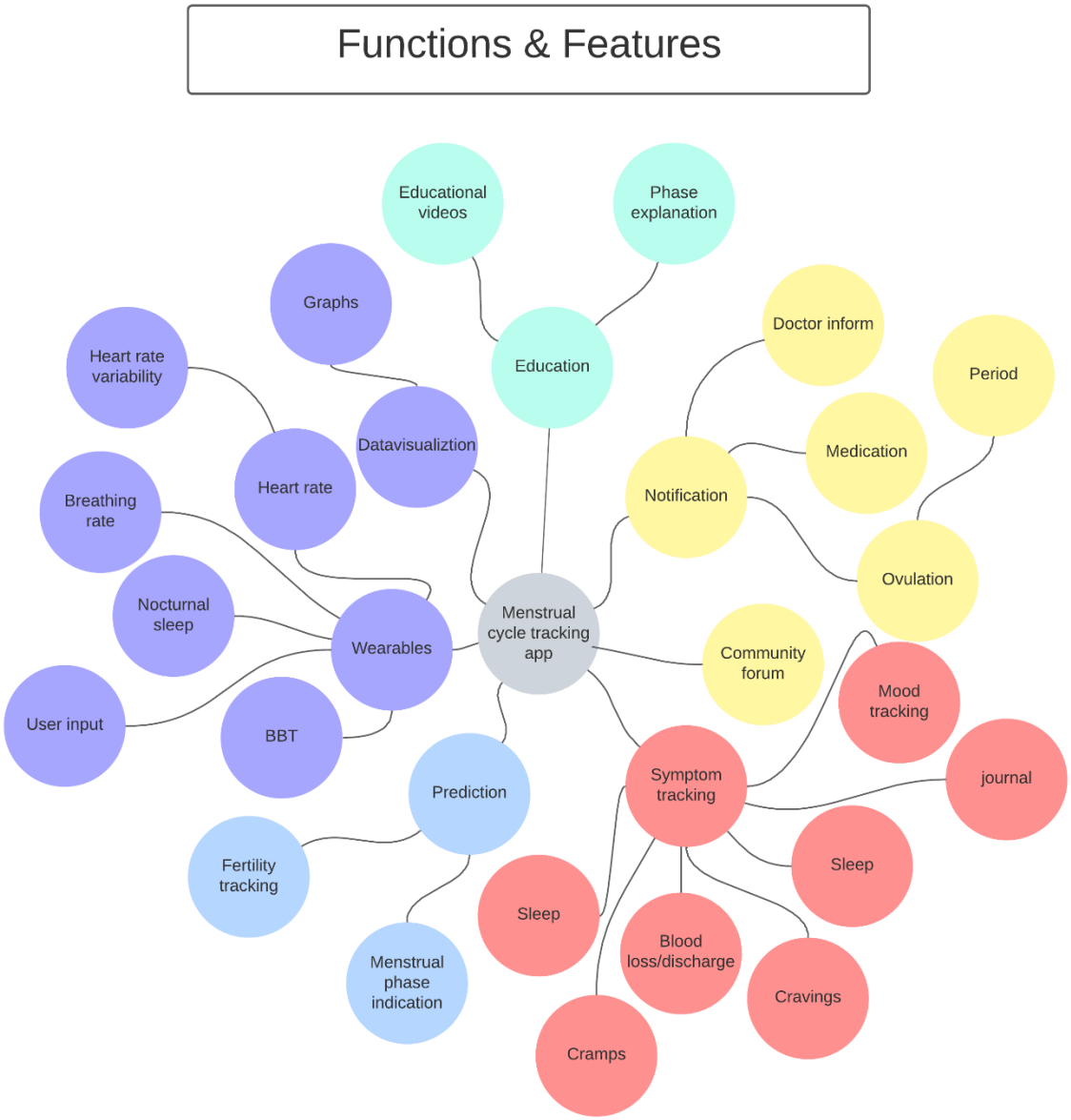


Figure 26 Brainstorm outcome of possible functions and features

Functions & features

Based on all the existing functions and features that are already existing in other applications of menstrual tracking apps, a selection has to be made on what functions will be incorporated in this project. The biggest limitations that is responsible for this selection is the time that is available for this project. The functions that will be incorporated are functions that are absolutely detrimental to the project.

Table 6 Selection table of features

	Used in this thesis	Why?
Calendar/prediction	Yes	Menstruation prediction is very important feature that the product needs to provide. The calendar needs to show in which phase the user is in at that moment. Period prediction is also one of the main problems that needs to be solved for the target group, since their menstruations are very unregular.
Mood tracking	Maybe	Mood tracking could be implemented, especially to explain what impact hormones can have on the users mood.
Community forum	Maybe	A community forum where users can share questions and experiences can be entering to implement, but also raises a lot of concerns since the forum needs to be moderated.
Journal	Maybe	A journal could be added, it might add a nice personal touch to the app and gives the user some space to write down information.
Characters/personas	Maybe	Some menstrual tracking apps that are already on the market that cater to the target group use characters/personas for the user to pick. This character guides them through the app and gives them information. Surveys and user studies need to be completed to see if the implementation of characters is actually something that the average target user likes.
Graphs (insight into measured data)	No	Products catered to 'mature' users like Ava Fertility and the Oura ring use a lot of graphs that showcase the data that is being measured. Although this is a good way to portray a lot of useful information, it might not be the best fit for the target group of this thesis. Younger users might get overwhelmed by the graphs. A graph showing them that their BBT is fluctuating will not be interesting for a 12-year-old user.
Sleep	No	Although some insight into sleep of the user can be quite interesting, it is not important for the target group to know in relation to their menstrual cycle.
Activities	No	The same case as 'sleep'.
Pregnancy and fertility	Maybe	Pregnancy and fertility can be implemented into the product, but only for educational purposes. Notifying when the users fertility window is won't be necessary because the app is not catered to users who are looking to conceive. Information about pregnancy is important to include, since the start of their first menstrual cycle also means that they are fertile for the first times in their lives.
Blood loss/discharge	Maybe	Although blood loss or discharge is an important feature to implement in the product, because the amount of blood loss/discharge says a lot about the users physical state, it is almost impossible to measure without becoming to intimate. Heart rate and BBT data are already enough data to have an accurate prediction of upcoming periods.
Education on menstruation	Yes	Educational videos or texts are obligatory to provide more insight for the target user group, since the main goal of this

	product is to guide first time menstruation and educate them on the physiological changes their bodies are going through.

From table 7 it can be seen that certain features are important to incorporate in the app. A calendar with period prediction is one of the most important features in the app since this is the most practical feature for the target user. First time menstruators have very unregular periods, and a notification of an upcoming period can help them be better prepared. The prediction includes a calendar that denotes when the next period will arrive, and a clear depiction of which menstrual phase the user is in currently.

The educational function is also important to implement in the app. The biggest characteristic of the target user is that they are new to the concept of menstruation and do not have a lot of practical knowledge because of the lack of experience. Educational functions include giving the user information about anything period related. The fact that user specific data is used will allow the app to give much more personal information since it can prepare data based on the specific menstrual phase the user is in at that moment.

All other functions mentioned in the table are also very useful, but are out of the scope for this project or do not specifically cater to the target user's needs. If time allows, more features can be incorporated into the application, but the base of the app needs to have at least the two previously mentioned functions.

Having specified the features that will be used in the app, it is now important to ideate what the details of these features are going to look like. Especially for the interface design. the results of the survey will be used.

How will the Calendar/prediction be visualised?

The calendar feature is one of the most important features that are in the app since all information gathered is visualised here. In one look, the calendar page must clearly state an overview of the month and when the period will take place in that month. Many menstrual tracking apps also lay a big importance on showing when the ovulation takes place, but that will be left out for this product since ovulation is not an important event for first time menstruators.

The choice of colour palette is supposed to be based off of the results of the online survey, but this is quite difficult since the liking of certain colours is very subjective. While some participants didn't like the busy and bright colours of the 'MagicGirl' app, some liked it and thought it was very appropriate for the target group. Although the 'OKY' was the most popular app chosen by the participants, there were also quite some participants that didn't like the colour scheme at all. The safest way to go about the design of the application for this thesis is to have a minimalistic interface with light colours. Minimalistic is chosen since the biggest negative feedback on apps was that participants thought the interface was too cluttered. Light colours are chosen since darker colours, like the Oura interface, got a lot of negative feedback. The minimalistic and light colour scheme is the safest way to go, maintaining a clear overview of the app while still being appropriate for the target group. The next chapter will show the actual designed interface for the app of this thesis.

Education on menstruation

Figure 19 displays some subjects that participants who have been menstruating for multiple years would have liked to know before they started menstruating. This graph gives good insight into what educational subjects to incorporate into the app, since the target user does not know that this could be very useful information for them.

The most frequent subject mentioned in figure 19 was 'how to use tampons', or more information about menstrual products in general. Next to this, participants also would have wanted to know more about the symptoms that are paired with menstruation and how to deal with it. The third most mentioned subject was about the normalisation of menstruation, meaning that the participants would have liked to feel more like getting your period was something natural and nothing to be ashamed of.

Data

While the design aspect of the app is figured out, the technicality behind it is not. Since the domain of this thesis is 'Lifestyle and Wearables', the application needs to be compatible on a wearable. The state of the art showed some applications that already use wearables to configure data into the app and are able to accurately predict the users' next period.

Ava Fertility and Oura are already on the frontlines with their research on finding the most accurate way to indicate a women's menstrual cycle. This is why the aim of this thesis is not on finding the most accurate way of menstrual prediction via wearables, but more on a way to convey this technology to the set target group.

Based on the findings in chapter 2, the most accurate predictions are done when multiple physiological variables are measured and sent into an algorithm that can extract menstrual patterns. BBT and HRV have shown to be the most accurate variables that can indicate different menstrual phases.

The implementation of live data obtained by a wearable, processed with an algorithms in an entirely newly programmed app is simply not feasible for the time scheme of this thesis. Part of this is because the user evaluation would then consist of participants wearing an wearable combined with usage of a new app for multiple months to see how accurate the app is in real life, which is not feasible with the time available for this project. Next to this, the importance of this thesis is not laid onto how accurate the application might be but more on the user experience of the application on the target group. This is why it is chosen to use a months' worth of pre-recorded menstrual data from a women who regularly wears a smartwatch. This dataset is then programmed into the app.

The way the application will work is to have it be based on the information of the data of a women, who we will be calling participant X. The app will have a page dedicated for navigation that is only used during the user evaluation to combat the lack of live data usage. This navigation page will showcase the menstrual data of participant X in a graph. The graph shows participant X's BBT data for one menstrual cycle. The person who will perform the user evaluation can see this graph and select a certain day from this menstrual cycle to see what the app would look like on that certain day. For example, if the participant in the user evaluation would select day 14 of the dataset, the app will retrieve the menstrual data that was measured on day 14 from the dataset of participant X. After the application has retrieved this data it will configure in which menstrual cycle participant X was in on that day and display the app according to the calculated menstrual phase. This means the countdown

of when the next period will arrive will be recalculated and the advice the app will give to the user will also be personalised based on the given menstrual phase.

This way, the application can still be fully evaluated within the time scope available for this project.

Conclusion of ideation

From the ideation process a certain set of conclusions can be drawn of what the thesis product will entail and how the user experience follows when the product is used.

Application

The app includes three main features, a clear main page that states when the next period is due and in which menstruation phase the user is in at the moment, a calendar with period prediction and a page where the user can enter the symptom they are experiencing which will direct them to another page that educates them on the symptom and relates it to their menstrual cycle.

The user experience

What makes the product stand out from other menstrual cycle tracking apps is how it puts a lot of emphasis on that the user experience has to cater exactly to the needs of the target user. Many women feel shame or embarrassment around the topic of menstruation in their first years of menstruation, which is why a certain level of secrecy is fundamental to let the users have a comfortable user experience when using the app. This means that the app name and icon do not have to be blatantly about periods nor does the design of the app.

Next to secrecy, the design of the app should be calm and inviting, while not being too colourful or ‘girly’.

With the knowledge that the stakeholder analysis, state of the art, online survey and brainstorm has provided, the specification of the actual application can start. This will be done in the next chapter.

Chapter 5 – Specification

The conclusions made in the ideation phase show that the app should entail a main page, a calendar with prediction mechanisms and a page that can inform the user about the state of their menstruation and what they can expect. Each of these pages have to have a clear layout, with a playful design that is not too busy nor childish and should not eye too much like a standard menstrual tracking app.

Figure 27 shows the mock-up design of the application

Figure 27 Mock-up design of application

The calendar page needs to be able to show the user in one look when their next period will start and end. Any other feature is unnecessary on this page and will only confuse the user.

On the front page a button is placed named ‘Add symptom’. This feature leads the user to a new page where they can pick a symptom that they are experiencing at the moment, i.e. fainting. Based on the symptom and menstrual phase they are in, the user will be directed to a new page that gives them information about the symptom, stats on how common the symptom is and how to combat the symptom. In the case of fainting, most of the time the reason is that the blood loss during the menstruation accounts for an iron drop in the body which can lead to fainting.

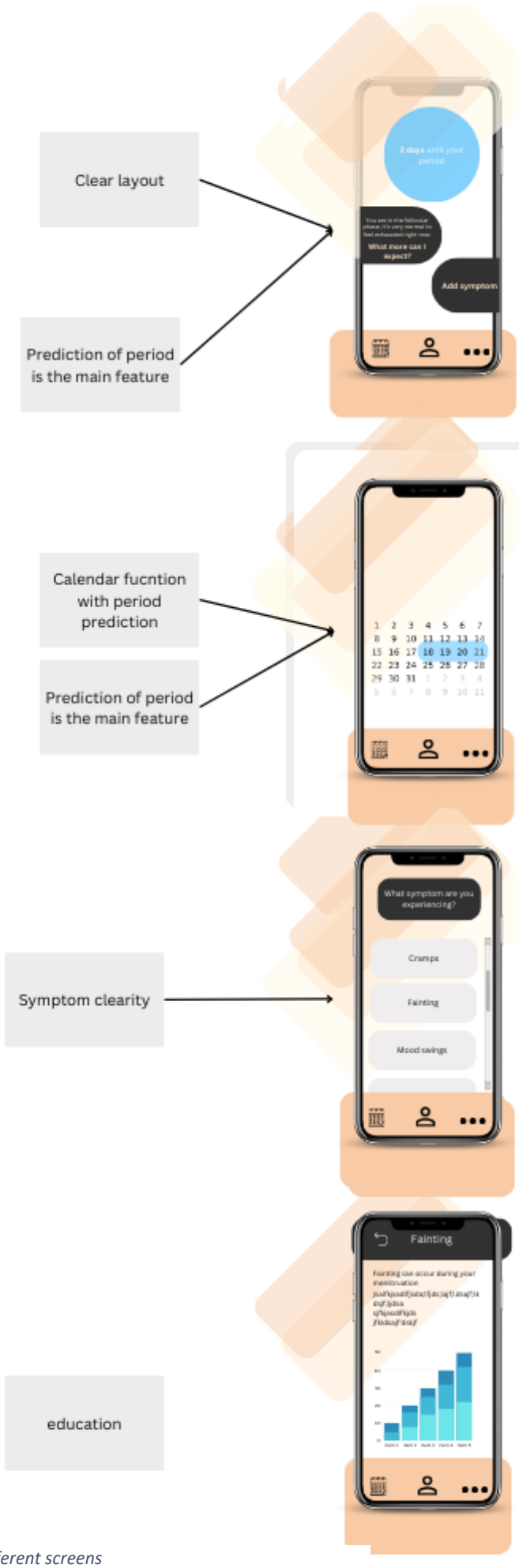


Figure 28 Features of different screens

Table 7 Table of Requirements

Functional requirements	Non-functional requirements
Product shall include a calendar	Product shall inform the user clearly in which menstrual stage they are in
Product shall integrate the collected menstrual data correctly and safely into the app	Product shall inform user properly what their menstrual stage might inflict on their body
Product shall clearly inform the user of when the next period is due	Product shall handle all data properly
	Product shall be appropriate for the target user

These (non)functional requirements have been set with the main stakeholders, the target users, in mind. The requirements strive for the product to act as a standard period tracking app with accurate period prediction using data obtained by a smartwatch, while also being focussed on granting the user experience pleasant and educational for first time menstruators.

Data specification

The dataset has been obtained with consent from participant X, who is a women around the age of 25. The raw data is measured by a Fitbit Charge 5 and only the basal body temperature is used for this application

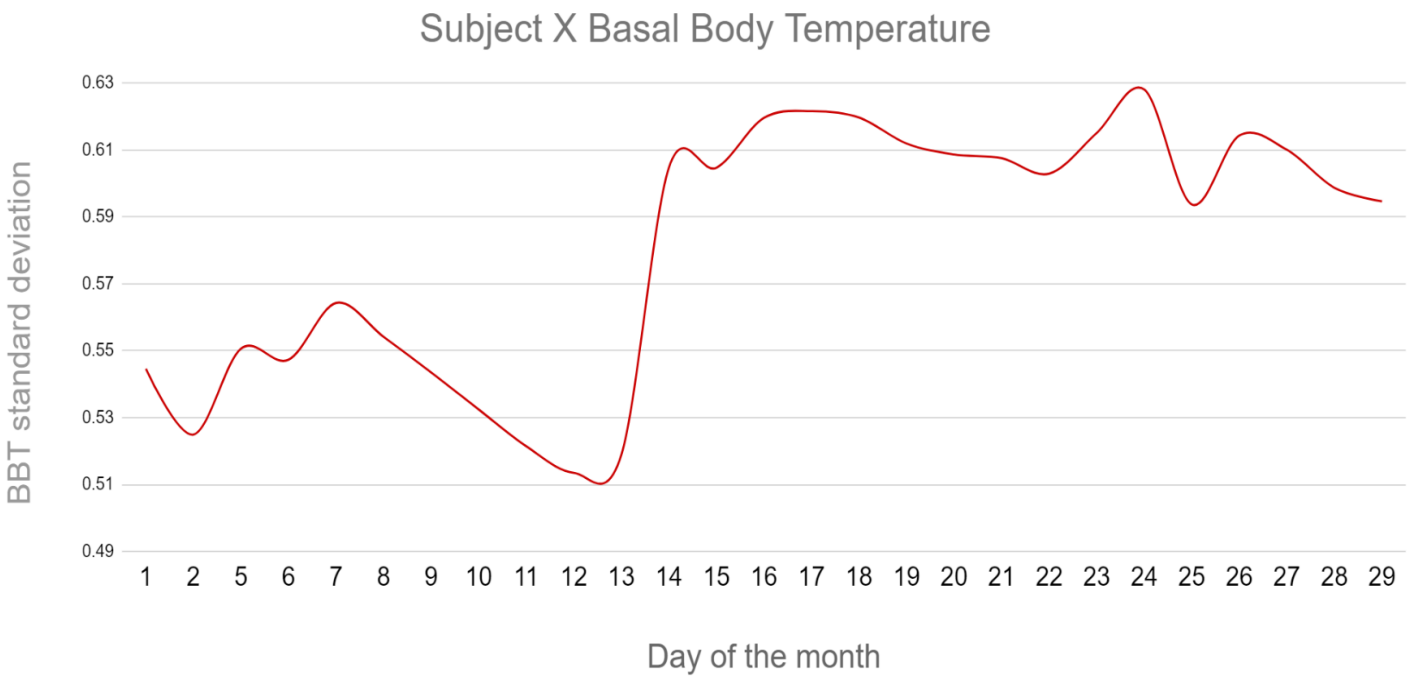


Figure 29 BBT graph of participant X

Figure 29 shows the plotted BBT data of a randomly selected month that was measured of participant X. The next step is to indicate the menstrual phases of this month. The Fitbit notified that participant X had her period from day 1 until 7, and the period after that started on the 30th of the oncoming month, which is why this dataset stops at day 29 since a menstrual cycle restarts at the first day of a new period.

The ovulation can be seen on day 13. This is because the ovulation is the day where the BBT has the highest ascent, according to the research in chapter 2. This automatically means that the days between the first period and ovulation are the follicular phase, and the days between the end of the ovulation and the next period are the follicular phase. PMS symptoms usually appear within the last 5 to 11 days of the luteal phase, but varies heavily per person and also per cycle (Yonkers & Simoni, 2018). Graph 30 shows the same graph as above but now with an indication of menstrual phases.

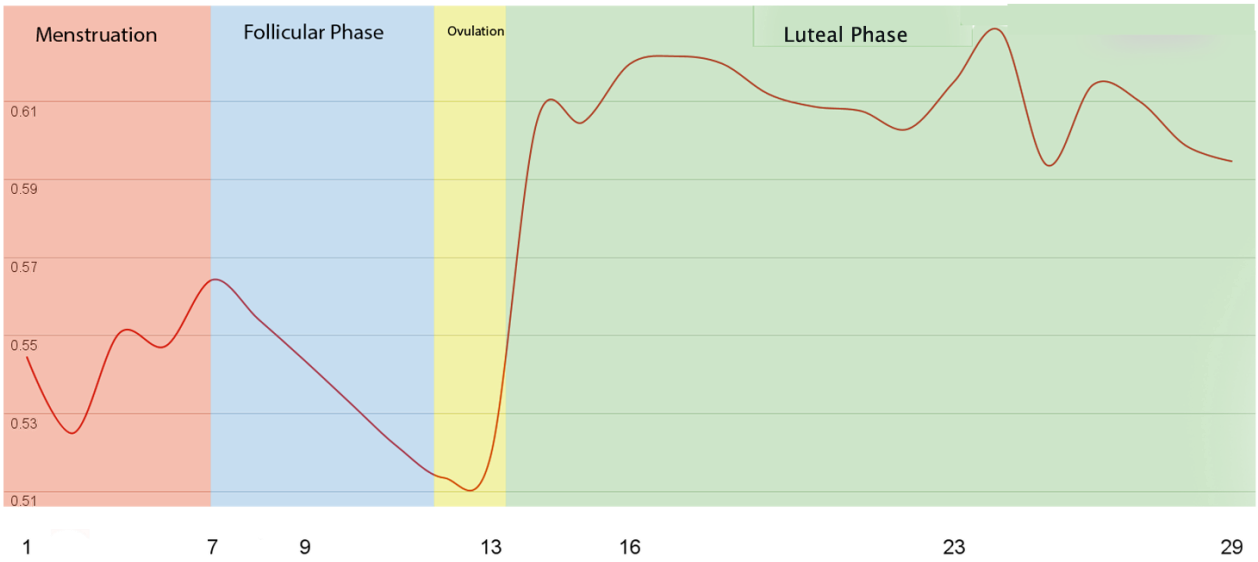


Figure 30 BBT data graph of participant X with denoted menstrual phases

With all aspects of the application being specified, the development can now begin. The next chapter will present this.

Chapter 6 – Realisation

Since the specification has been completed, the programming of the actual app can be started. The app is made in Flutterflow. In figure 31 all of the pages of the app can be seen and also how they interact with each other.

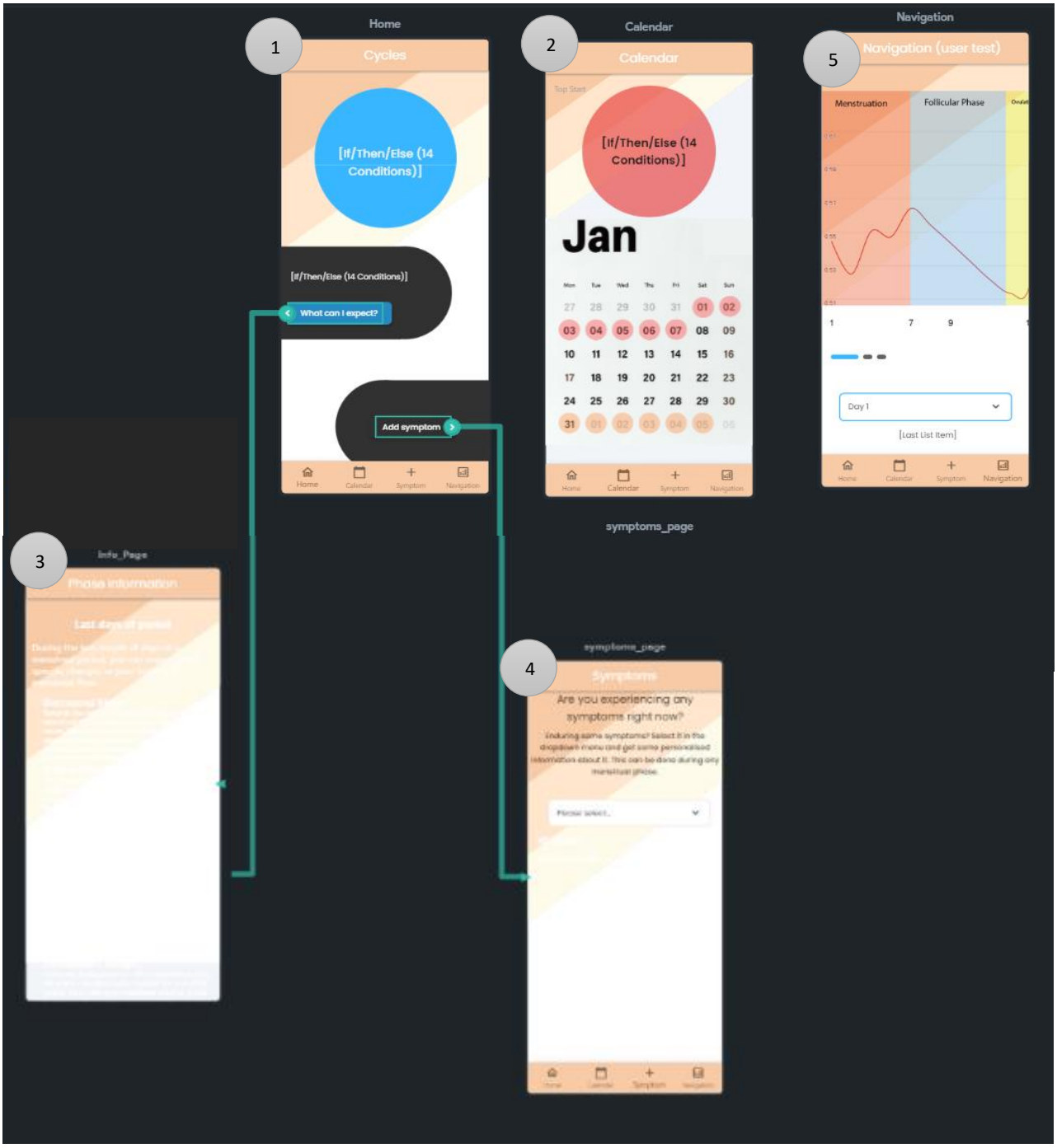


Figure 31 Overview of the different application screens

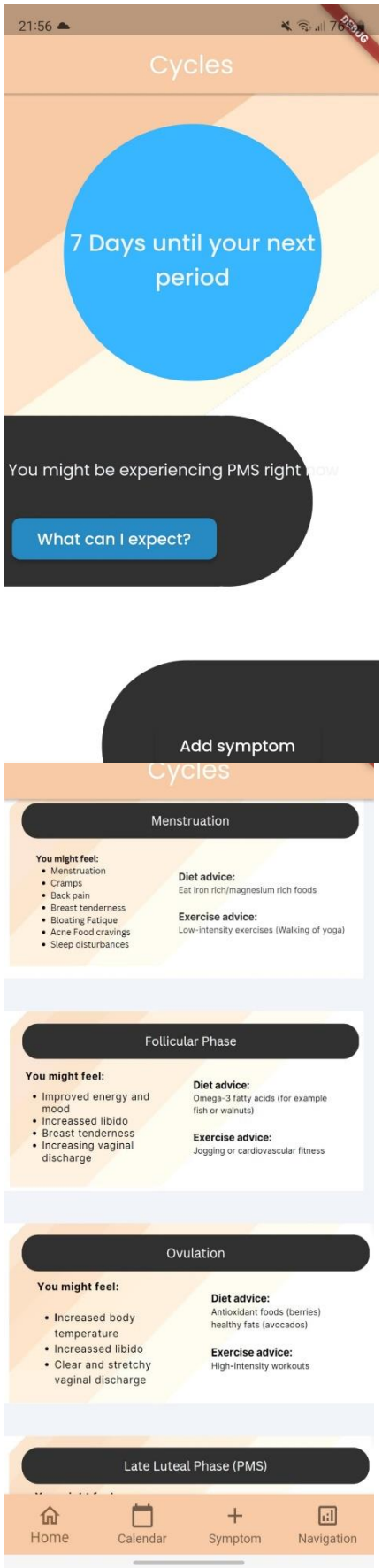


Figure 32 Main page if user were to scroll down

1. The main page

The main page shows a blue circle with text indicating when the next period will arrive for the user. Below this is a text that informs the user in which menstrual phase they are currently in and what they can expect from this phase. Below that is another button that says 'Add symptom'. If the user is experiencing any type of symptom, like cramps or fainting, they can press the button and a new page will give them information and advice on said symptom.

If the user were to scroll down on this page, they would see the screen depicted in figure 33. Here, four images are shown that give information on the different menstrual phases the user can experience. The information entails possible symptoms and diet/exercise advice.

Figure 33 Calendar page

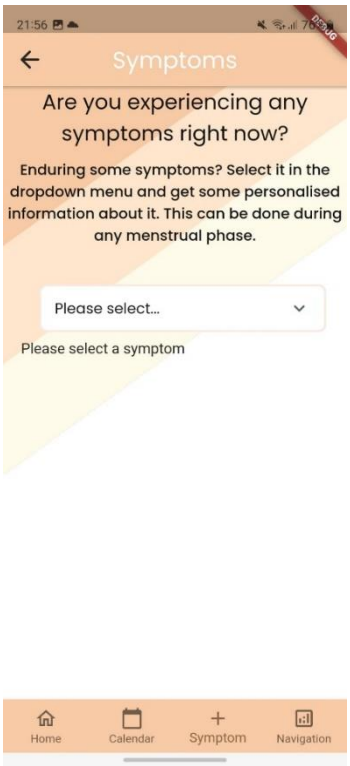
2.The calendar

The calendar has a large central text that displays how many days till the next period the user has left. Below this is a calendar that for now is not usable since the app is only working on a dataset. If the app would be further developed after this thesis, the calendar would be interactive, meaning that the user could scroll through the months, seeing each month when their period would be. If the actual period would differ from the predicted one, the user should be able to change this in the calendar.

Figure 34 Phase information page

3.Phase information

When the user presses ‘What can I expect?’ on the main page they will be taken to the phase information page. This page changes based on which menstrual phase they are currently in. The information entails some general information about the phase itself followed by the symptoms the user might experience and how they can deal with it.



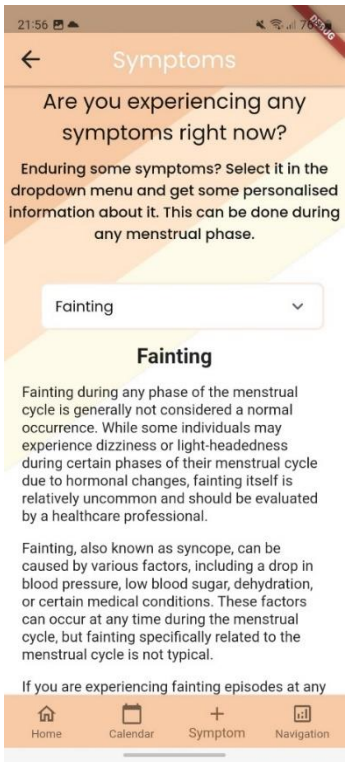


Figure 36 Symptoms page

4. Symptoms page

The user is navigated to the symptoms page when they click 'Add symptom' on the main page. This page consists of a dropdown menu that contains four popular types of symptoms that women might experience during their menstrual cycle, which are fainting, cramps, mood swings and anxiety/depression.

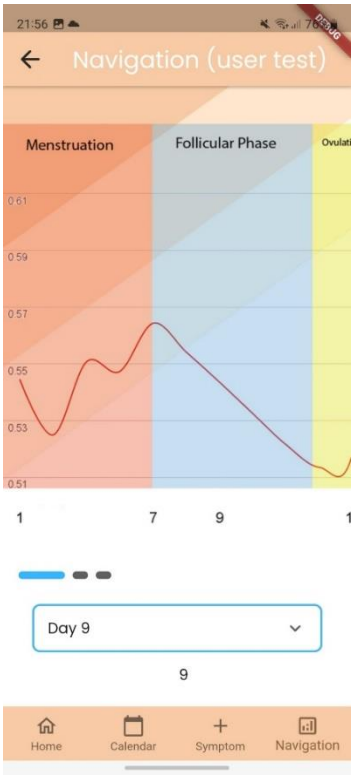


Figure 37 Navigation page (only used for user evaluation)

5.Navigation page

The app made for this thesis does not respond to live data yet, but it does use a dataset that has the BBT data from a women that has been collected of her for a month. On the navigation page a graph is seen where the temperature deviations are plotted against a timeline of 29 days. The different phases have been depicted by colours in the graph, which are based on the BBT data.

This page is only used for the user evaluation, and would not be included in the actual app if it were to be continued after this thesis since it would have real life data to work with. This also means that the participants in the user evaluation process will not be giving feedback on this particular page.

The participants are able to scroll through the entire dataset of the women's month and below the image is a dropdown menu where they can select certain days in the month. When a certain day is selected, the entire app changes based on how the app would look like on that particular day.

Figure 35 Overview of possible information in app based on selected day and symptom

Chapter 7 – Evaluation

With the design of a new system, an user evaluation should be performed to see if the requirements set in the beginning of the design process are met. This chapter will explain how the evaluation will take place and what exactly is asked from the participants who are participating.

The user evaluation is done with 7 female participants. All participants are between the age of 18 and 30.

First off, they will get informed about the grounds of this thesis and the nature of this app. The participant will sign the informed consent form. Actual first time menstruators are difficult to recruit for this thesis since they are under the age of 18, and ethically this is difficult to get approval for. This is why the participants are asked to go through this user evaluation process as if they were at the age of when they were first menstruating. If the participant started menstruating around the age of 14, this means that they will answer every question as if they were 14 again. To get into this headspace, the participant will answer some beginning questions that bring them back to the time they were first menstruating.

Beginning questions

1. How old are you right now?
2. How old were you when you had your first menstruation?
3. Think back to the time you had your first period, how did you experience it? Did you have anyone around you to help you?
4. How did you feel around the concept of menstruation?

The only thing about the app that is explained to the participant is the navigation page. This page is only used for user evaluation testing and works as follows.

Since the app is not working with live data obtained by users, the app uses a pre-set dataset of another women.

The navigation page consists of a swipable graph that denotes an actual BBT dataset of women that has been collected for a month with a Fitbit. The graph denotes the different phases of the women's menstrual cycle for one month, with day 1 consisitng of the first day of the actual period, the seventh day being the overlap of menstruation to follicular phase, ninth day the middle of the follicular phase, day 13 being the ovualaiton, day sixteen the beginning of the luteal phase, day twenty-three being the biginning of the PMS and the last day of that months menstrual cycle, day twenty-nine, being the end of the PMS. This page is not used in the actual app but only for the sake of user evaluation since the participant needs to have a way to nagivate through the app.

This is explained to the participant togeter with the dropdown menu below the graph that they can use to select a certain day in the menstrual cycle to see how the app would react as if it was that actual day.

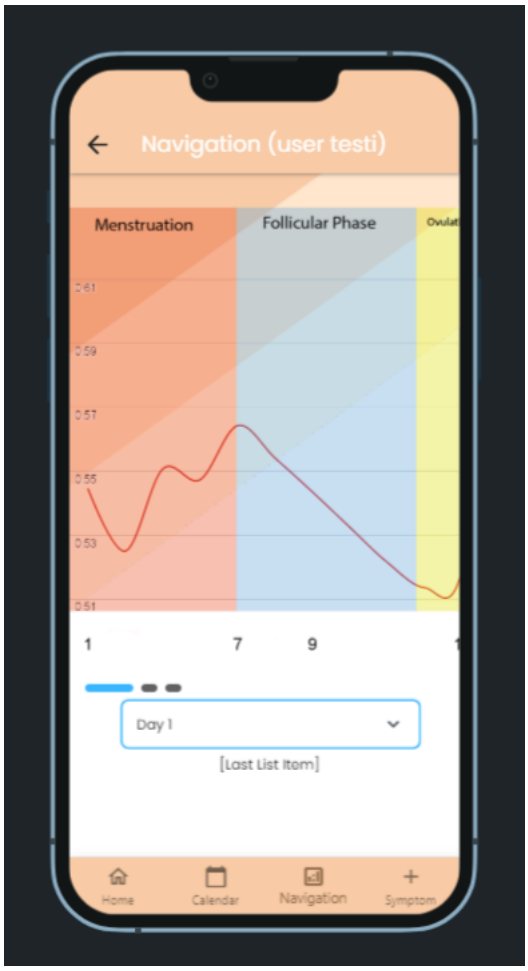


Figure 36 Navigation page

The thinking out loud method will be used during the user evaluation to get direct feedback on what the user thinks of the app at that moment.If the participant does not have any remaining questions about the navigation page they will get the app in their hands and get five minutes to look through it to get some first thoughts out.

After these five minutes the participant is asked to perform five tasks. These tasks have been set in place to have the participant experience the app as if they would have used it for a month of their own cycle while also utilising every feature the app has to offer in a structured manner.

Task list

1. On day 1, you are on your period. You are having heavier cramps than last time. See if the app can give you information about this.
2. On day 9, you are finally done with your period but you still feel a little moody. See if the app can give you information about this.
3. On day 13 you open up the app and see that you are ovulating. You have heard of this word but do not know what it entails for your body. See if the app can give you information about this.
4. On day 23 you start to get cranky, a boy asks you if you are PMS'ing. You have no idea what this means. See if the app can give you information about this.
5. On day 29 you fainted after gym class. Your PE teacher told you that it might be because of having your period. See if the app can give you information about this.

Now that the participant has looked through all the usages of the app, the list of requirements has to be inspected and evaluated to see how well the product performs. This is done with a questionnaire.

The main questions that have to be answered are below.

1. What do you think about this app?
2. What have you learned?
3. How could the app be improved?
4. Are there any important functionalities missing?
5. Would you use this system?
6. Give comments on if this app would be appropriate for young menstruators.

Now that the evaluation is done, the participant is thanked for their participation and asked if there are any last comments or questions they might have.

Results of user evaluation

The user evaluation has been conducted with 7 women who are all students at the University of Twente. The following paragraphs will explain the results of the user evaluation.

The following tables will show the most important feedback points that came out of the user evaluation per participant. The point of the evaluations is to see if the product are meeting the pre-set requirements. These requirements entail:

Table 8 List of Requirements

Functional requirements	**Non-functional requirements**
Product shall include a calendar	Product shall inform the user clearly in which menstrual stage they are in
Product shall clearly inform the user of when the next period is due	Product shall inform user properly what their menstrual stage might inflict on their body
	Product shall be designed in an appropriate manner for the target group

PARTICIPANT 1
AGE: 21
GOTTEN PERIOD AT: 12

INITIAL REACTION/FEELING AROUND MENSTRUATION	A little annoyed, didn't scare me too much.

Positive feedback

Aesthetic/ layout	Usability	Information/text	Functionalities	Target group appropriate
	Very easy to use	Good information, but too much text. It should be more compact since I wouldn't want to read all of this when I'm 12.	Nice and soothing.	

Negative feedback/improvements

Aesthetic/ layout	Usability	Information/text	Functionalities	Target group appropriate
Use more icons/pictures/images		Write easier text	System to save symptoms	The text should be made easier to read.
The option for customization				
Schematic with which phase you are currently with what you might experience is better				

Table 9 Participant 1 user evaluation results

Participant 2 **Age: 20** **Gotten period at: 15**	
Initial reaction/feeling around menstruation	Normal, I was prepared. It was a little hassle to deal with in the beginning. Not a lot changed for me personally, I was prepared. I didn't need any help, that would make me feel uncomfortable. I thought having your period would be worse than it turned out to be.

Positive feedback

Aesthetic/ layout	Usability	Information/text	Functionalities	Target group appropriate
	Easy and clear to use.	A lot of information, more info than I would ever look up myself, but very useful.		Very nice for if you are 15, because you don't know anything.
		It is nice that the app tells you that some symptoms are normal to experience.		
		Too much text, overwhelming		
		Diet advice is a nice add on		

Negative feedback/improvements

Aesthetic/ layout	Usability	Information/text	Functionalities	Target group appropriate
	The actual adding of symptoms that are then placed on a timeline, instead of just one big piece of text.	Put the text in sub headers instead of one big piece of text.		
	I want to go through the previous months in the calendar.			
	Make the cards with information that are on the bottom of the home page bigger, they are a bit hard to read.			
	For the exercise advice per phase, maybe you should link that with the fitness app of Fitbit.			

Table 10 Participant 2 user evaluation results

Participant 3 **Age: 21** **Gotten period at: 15**	
Initial reaction/feeling around menstruation	Very happy since I got it really late. My mom and friends helped me with it. I never felt weird around the concept of menstruation.

Positive feedback

Aesthetic/ layout	Usability	Information/text	Functionalities	Age appropriateness
Nice colour palette, I don't like the sudden black containers on the main page though.		Good information for all the symptoms.		
I like that you clearly see what you can expect and you know what this entails for you and if your menstrual cycle might be the reason for it.				

Negative feedback/improvements

Aesthetic/ layout	Usability	Information/text	Functionalities	Age appropriateness
		Text is too long, it would fit more to the demographic if it had more images.	The possibility to add symptoms on certain days in the calendar itself. This way you can compare it to previous menstruations.	

Table 11 Participant 3 user evaluation results

Participant 4 **Age: 20** **Gotten period at: 11**	
Initial reaction/feeling around menstruation	I was very confused, I didn't like it and I had no idea what was happening. My mom was there to explain stuff to me.

Positive feedback

Aesthetic/ layout	Usability	Information/text	Functionalities	Age appropriateness
Very nice and clear home screen.	Very clear and easy to use	Very useful information		
	Could have definitely helped me when I was younger	Nice to see what you can expect		
		I really like the diet and exercise advice, especially because your hormone levels have a great influence on how much you muscles can take.		
	Although I don't like orange, I do think it's good that the colours of the app are not too girly (not too pink)	Really like that the app brings information in a mature way, instead of still treating you like a little girl		

Positive feedback/improvements

Aesthetic/ layout	Usability	Information/text	Functionalities	Age appropriateness
I don't like orange			It's a little weird that the images on the main page with information about the different phases are always there instead of only when you are in a certain phase.	
			Add more symptoms that can be selected	
			Make it so that the symptoms are also stored somewhere so that you can look back on when you had a certain symptom	

	I want to click on the days in the calendar and see what I filled in on those days

Table 12 Participant 4 user evaluation results

Participant 5 **Age: 21** **Gotten period at: 14**	
Initial reaction/feeling around menstruation	My mum was around to help me, and I feel like it is a topic everyone should feel comfortable discussing.

Positive feedback

Aesthetic/ layout	Usability	Information/text	Functionalities	Age appropriateness
Looks cool!		and the functions are super cool and informative.		
The app looks super cool, neutral to hit a lot of different demographics within young teens, the colours are super neutral and easy on the eyes,				

Negative feedback/improvements

Aesthetic/ layout	Usability	Information/text	Functionalities	Age appropriateness
		There's quite a lot of text to digest, I feel an infographic might be easier on the teens to understand initially, or like a video. I mean as a kid I did read a lot online if I felt it was important to me, but if it was in an easy video format or poster, I think I would be less overwhelmed	maybe make it customizable for the user by letting them select a colour palette, this can help them feel that the product is more personalized towards them which can increase engage and use	

Table 13 Participant 5 user evaluation results

Participant 6 **Age: 26** **Gotten period at: 14**	
Initial reaction/feeling around menstruation	I don't really recall the exact moment when it happened, but I think I could talk about it with friends and my mom who explained what had happened. Menstruation felt awkward, very awkward.

Positive feedback

Aesthetic/ layout	Usability	Information/text	Functionalities	Age appropriateness
No unnecessary features or functionalities		The information is clear and to the point		
I like the colours and its simplicity				
I like how everyone you need is there and it's very easy on the eyes				

Negative feedback/improvements

Aesthetic / layout	Usability	Information/ text	Functionalities	Age appropriateness
			Personally, I like menstruation apps that display a tracker. Like a mood and symptom tracker, so that you can see how your mood has shifted over the past days. This can be in the form of a graph or something more creative like a tracker that is often made in Bullet Journals on Pinterest	
			And maybe also a functionality featuring uncommon symptoms, so girls know when to contact their GP when experiencing symptoms that could signal a health issue	
			You could think about expanding the app with more functionalities regarding pregnancy or risk of getting pregnant (fertile window). Young girls might not necessarily want to get pregnant but it might be good to also educate them on their fertile window	

	and when chances on getting pregnant are increased. (And thus when they should be very aware of having safe sex)

Table 14 Participant 6 user evaluation results

Participant 7 **Age: 26** **Gotten period at: 14**	
Initial reaction/feeling around menstruation	I had an older sister. She had already gotten her first period a couple years before me, so when I got my period I immediately knew what was going on. I just went up to my mom, explained that I had started my period, and then she explained about the different feminine hygiene products I could use. So at home it felt like a normal topic that could be discussed openly. At school was a whole different situation. I remember the boys asking if we were on our periods if we were annoyed with them. And having to hide the feminine hygiene products when we grabbed them out our bag to go to the toilet. It felt like we were regarded as gross while on our period, and like it should be something that no boys around you should notice. I was super excited to get my first period. It felt like I was finally 'a woman' now. And then I had a period the month after and I was already over it. I wanted to end that subscription, have not been able to yet. Even my dad was relatively awkward when I told him I had had my first period and needed him to buy me feminine hygiene products for whenever I'd be over. I remember going into the supermarket and him 'leaving me alone for a bit' so I could pick out the products I needed.

Positive feedback

Aesthetic/ layout	Usability	Information/text	Functionalities	Age appropriateness
I like the design and the colours. It is simple and clear which allows for an easy overview. It is easy to find the functions you're looking for.	If I would have had access to this I would have definitely used it. I remember my period being incredibly irregular (at least that is what it felt like, because I was not tracking anything). It	Additionally, I sometimes found it hard to figure out what to do about certain symptoms in situations where I wasn't at home. So the information could have really helped.		

		would have been really nice to have access to a tracker like this to easily create an overview of when I had had my period and when I would most likely be having my period.		

Negative feedback/improvements

Aesthetic/ layout	Usability	Information/text	Functionalities	Age appropriateness
		I see that you use the terms like Follicular Phase and Luteal Phase, but honestly I wouldn't really know what or when that is. So for that one maybe you could add a little text or subtitle saying: "During week 1 and 2 of your cycle". So I would just make sure that the writing in the app is not too medical and adjusted to a target audience of the age of a first menstruating person.	In terms of information, if you really want to deck out this app. You could also provide recipes that will help counteract certain symptoms or exercise plans that would be doable in that certain phase of the cycle. I saw that it already has small recommendations like 'iron rich meals' or 'go jogging', so that's great	Besides some of the terminology used, which I covered in question three, I feel that this app is perfectly appropriate for young menstruators. It gives background information on periods and the possible symptoms, which can be very nice to have when you start menstruating. It's great that there's a disclaimer indicating that everybody is different and when needed they should contact a GP
			I know that this app is meant for teenagers, but if you want to expand the target audience you could also add a function that tracks fertility window. I have seen that quite a	

	bit on menstruation apps. Although I personally really like it when you can turn off this feature as well. Because it's kind of odd if by default your app tells you you're fertility window is now, and you're like 15 years old and sitting in Math class
	Maybe allow people to indicate the symptoms and the severity level of the symptoms they are experiencing. So for instance, you're experiencing cramping, rate this from 1 to 5. To be fair I did see an icon in the tab with a plus and the word symptom below, but that functionality was not covered in the video so I am not entirely sure what that functionality looks like
	Additionally, you could have a notification on the day the period is supposed to start, asking whether indeed the period had started

Table 15 Participant 7 user evaluation results

The user evaluation summarized

The results of the user evaluation show that the application made in this thesis does perform well regarding the requirements that were set in the beginning of this thesis. Participants liked the interface, deeming it clear and easy to navigate through. Especially the diet and exercise advice per menstrual phase was a nice touch that a lot of participants liked.

The main takeaways from the user evaluation were that the text that is shown on the phase information and symptoms page is too long, and some of the words are too difficult for the target group. Images/videos should be incorporated into these pages to keep the attention of the target user, since long pages of text won't motivate them to read it all.

The saving of selected symptoms should also be incorporated into the application, since there is no option to do that yet. This way, users can see on which days they typically endure certain symptoms.

Customization of the interface might also invite more users to personalise the app so that the colours are more to their liking. Participants deemed this to be quite interesting for the target group.

Now that the application is evaluated, the research questions can be answered.

Chapter 8 – Conclusion

The menstrual cycle consists of four phases, the period, follicular phase, ovulation and luteal phase. Women tend to get their period around the age of 12, but this differentiates per person. Especially during the first couple of years, a women's menstruation is very unregular since the hormones are trying to find a balance.
Period tracker apps that use physiological data from wearables typically use BBT and heart rate variability to depict in which menstrual phase the user is currently in. This method has a higher accuracy fore predicting the onset of menstruation than user input.

There are already quite some products on the market that have a high accuracy as a period tracker, but none of these are specifically tailored to the target group of this thesis, young menstruators. This is a big loss, since the young menstruators can benefit highly from a good period tracker that is catered to their needs. As seen from a survey conducted over 64 women, it can be concluded that young menstruators want to clearly know when their next period is coming and what they can expect during their menstrual cycle, together with personalised advice communicated to them in a mature way. A period tracker app can provide all of these aspects in a private way.

The second half of the survey participants had to give feedback on four interfaces of already existing menstrual tracking apps. The results of the survey indicated that the target user wants an application that clearly states when their next period is due and what they can expect during their menstrual cycle. The information in the app needs to be brought in such a way that is understandable for them but at the same time is not perceived as too childish so it does not diminish them. Design and aesthetic is always a personal opinion, but generally participants likes a light minimalistic design that has a balance between girly and mature. While other apps use graphs indicating their measured physiological data, the results of the survey show that this is too difficult and redundant for the target group and should be left out of the final design. The app does not necessarily have to have many functionalities, the most important ones are a countdown to their next period, a calendar and a way where they can find/see more information about what is currently happening to their body.

With the results of the survey the actual application is made and an user evaluation is conducted. Seven women have done an evaluation process where they go through a task list with the app while being filmed. The task list entails some scenarios that a target user might go through when using the app. The entire evaluation is done with the thinking out loud method and afterwards a semi-structured interview is conducted where the participant gives their final thoughts about the application.

The results of the user evaluation show that the application largely completes the requirements set in the beginning of the thesis. Most participants find that the app works well and is able to convey all the functionalities that it has to. The results of the user evaluation also give some feedback on the weaker points of the application and state what improvements it can make. The biggest feedback points are that the information in the text is too difficult for the target group and also too long. The text should be redistributed into smaller sections and more icons/images should be used. The symptoms that are selected by an user should also be able to be saved somewhere in the system so that it can be used for comparison in future menstruations.

With the information that is found within all chapters of this thesis, the research questions that were set in the beginning can be answered.

How can apps and wearables assist young menstruators in understanding and coping with their menstrual cycles?

1. What are the common challenges faced by young menstruators when it comes to understanding and coping with their menstrual cycles?
2. What features can be incorporated into apps and wearables to enhance young menstruators' understanding of their menstrual cycles?

The first sub question stands within the domain of the target user's characteristics and needs. The survey conducted in chapter 7 put some light on the main challenges of what women go through during their first years of menstruation. The foremost problems women encountered were that many women were helped by their mother when they first got their menstruation but this is not the case for all women. Multiple women mentioned that they didn't have anyone that could help them in the beginning. This is concerning because 62% of the participants said that they experienced moderate to extreme cramps and half of the participants experienced moderate to extreme mood swings, all in the first 2 years of their menstruation. Participants who said that they experience moderate to extreme symptoms that these symptoms did disturb their day to day life, interfering with school and some even bedridden. While this is already annoying enough, most participants also mention that they had extremely irregular periods in their first 2 years. The most prominent challenges that young menstruators go through are moderate to extreme symptoms that suddenly set on after they had their first period and extremely unregular periods that leave them completely unprepared. Some participants didn't even know that the symptoms were menstruation related and were even more uneducated on how to deal with them.

This information is also useful for the second sub question, because based on the challenges of the target group certain functions have to be incorporated. Period tracking apps based on wearable data can predict the oncoming period with relatively high accuracy for the user. From applications discussed in the state of the art in chapter 2 it can be concluded that period trackers that use multiple variables have the higher accuracy than period trackers that only use one variable. The main variables that are used are the basal body temperature and heart rate variability. Algorithms can be set in place to collect incoming data from the user and detect patterns in their menstrual cycle, which is especially handy for this target group since they have irregular cycles. Next to period prediction, the app should also hold a function that gives the user room to select certain period symptoms so that they can get personalised feedback on why they are experiencing it and how to deal with it. The application should convey the information that is appropriate for the target group.

-

Chapter 9 – Discussion & Future Work

The survey that was conducted in chapter 7 showed some insight into some problems that were not initially mentioned during this thesis. One of these problems is the lack of authority figures that can help and educate the target group about any doubts or questions they have regarding their menstruation. The application made in this thesis can provide a good foundation for young girls who lack any authority figures where they can confide in when they have doubt or questions about their menstruation. This application will also give scientific feedback that is backed up by research. This is especially conventional when an user does not have any older women in their environment that can speak to them from their own experience.

Another problem that this app can provide support in, is the support for young transgender usage. A participant in the online survey mentioned that they as a transgender man (female to male) would have appreciated an app that still tracks their menstrual cycle, while also supporting and educating them on how to deal with this while being a transgender. Especially since many young transgenders are hesitant to communicate their gender issues with people around them, an app that is secretive and lets the user know that all data obtained is private can provide support that they otherwise would not have (McDermott et al., 2017).

Limitations & recommendations for future work

While the application made in this project proposes some promising results and impacts on its users, there are quite some limitations in this study. Most of these limitations are result of time limitations.

While the app now only runs on a data set, this would not be the case if the application would be open for anyone to download. The goal is for the app to be compatible with most smartwatches, where they would obtain at least the BBT and heart rate data. As of now, the dataset only contains BBT data. For future recommendations, the app should be programmed to collect measured data from the users smartwatch and let the app calculate the menstrual cycle using algorithms to give accurate predictions, even if the user is experiencing unregular periods. If the application would be working with live data, the calendar page should also be updated to an interactive calendar that is updated regularly. The calendar as of now is only an image of a calendar with the days of the current period and next period highlighted. This should be converted to a widget that users can scroll through so they can see up to at least 4 periods ahead.

Another limitation that is the result of time constraint, is that based on the user evaluations there are still some functions in the app missing that would greatly improve the user experience. Participants mentioned that they would like a option to save symptoms in the calendar so that they can see when they have experienced certain symptoms. This way the algorithm could calculate patterns and notify the user when they might experience the symptoms again.

Participants from the user evaluation also mentioned that the information that is currently in the application might not be appropriately written for the target group. The text is too long and some words might be too difficult. Some participants mentioned that the usage of more images and videos can grab the attention more of the user. The long texts might put the user off of reading all of it.

Some other small additions that can be added in future development of the app include an option to customize the app to the users liking. This means that the user can select their own preferred colour palette. There should also be more symptoms included in the symptoms page, as of now there are only four options. The online survey also showed that quite some women would have liked to know how to use tampons and more information about menstrual products in general. This should also be added to the application since it has not been yet.

Appendix - 1

Menstrual cycle support technology

Dear reader,

For my thesis, I am developing a menstrual cycle tracking app specifically targeted towards young girls who have just started menstruating. The app uses personal data such as body temperature and heart rate of the user which is measured by a smartwatch. With this data, the app can determine the menstrual phase of the user and also predict when the next menstruation is due.

For my research, I need more information on what young girls need in the app, as I have only relied on my own experience so far. Therefore, I am asking you to think back to the time when you first started menstruating and to fill out this questionnaire.

Please answer all these questions based on how you would have answered them during your first 2 years of menstruating.

The questions can be very personal, so all answers are completely anonymous.

If you have any further questions, you can reach me at: Sil Dijkman s.dijkman@student.utwente.nl 0650542488

Thank you in advance!

1. How old are you right now?
2. Think back to the time you had your first period, how did you experience it? Did you have anyone around you to help you?
3. Did you experience any moderate to extreme symptoms during you first 2 years of menstruation?
    a. Moderate to extreme cramps
    b. Vomiting
    c. Fainting
    d. Increased anxiety or depression
    e. Mood swings
    f. Extreme fatigue
    g. Extreme backpain
    h. Diarrhea
    i. Sleeping problems
    j. Aggression
    k. Extreme cravings
    l. Extreme headaches
    m. Extremely unregular cycles
    n. Acne
    o. Extreme blood loss
    p. I did not
    q. Other...
4. If you clicked 1 or more symptoms in the last question, answer this question too. When did these extreme symptoms start and did they disturb your day-to-day life? How did you deal with them?

5. How did you feel around the topic of menstruation? Did you find it embarrassing or shameful?
6. What did you do/use when you had any questions around your own menstruation?
    a. Internet/Google
    b. Sex education
    c. Parents/custodians
    d. Friends
    e. Books
    f. Apps
    g. Never had any questions
    h. Other…
7. Is there something you would have liked to know or expect before you started menstruating?
8. Are you using a menstrual cycle tracking app, or have you used one? If so, which one?
    a. Clue
    b. Flo
    c. Eve
    d. I don't use one
    e. Other…
9. This is the interface of the app 'MagicGirl', a menstrual cycle tracking app that's made for young girls. Would you have used it when you were first menstruating? Answer yes/no and explain why based off the colors, functionalities, aesthetic, name and design. Are they aspects that put you of?


10. This is the menstrual cycle tracking app of 'Ava Fertility', which is mostly tailored to women who are trying to conceive. Would you have used this app when you first started menstruating? Answer yes/no and explain why based off the colors, functionalities, aesthetic, name and design. Are they aspects that put you of?

11. This is the menstrual cycle tracking app from Oura. Would you have used this app when you were first menstruating? Answer yes/no and explain why based off the colors, functionalities, aesthetic, name and design. Are they aspects that put you of?

12. This is the interface of the 'OKY' menstrual cycle tracking app, which is specifically made for young girls. Would you have used this app when you were first menstruating? Answer yes/no and explain why based off the colors, functionalities, aesthetic, name and design. Are they aspects that put you of?

13. Thank you so much for filling in this form! If you have any other things you wanted to mention, you can do so here.

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