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MONITORING USAGE PATTERNS IN THE SAMPOORNA PROJECT

ECODEV SOLUTIONS – UNIVERSITY OF TWENTE – CREATIVE TECHNOLOGY
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Abstract

This Bachelor's graduation project is about monitoring usage patterns in the Sampoorna project. The Sampoorna project consists of two machines – a sanitary napkin vending machine and an incinerator – that are located in schools in rural areas of India and was started by the company EcoDev Solutions. The machines are used by the local girls to get new sanitary napkins cheaply and get rid of their old ones in a responsible way.

In order to improve these machines, a system is proposed that will collect useful data from both machines and send it to the social workers involved. Parts of this information sent will be personal information, so that social workers know which girl is using the machines correctly and which girl is not. In order to accomplish this goal, telemetry is used. Telemetry modems can keep track of what is happening with the machine concerning inventory, maintenance, etc. This system can be combined with an NFC reader on the machine. Users can scan their personal token here, which allows the machine to read their personal information and connect it to their purchase, for example.

All of this is needed to help the girls' in these areas to get a brighter future. Even now, taboos on menstruation still heavily rule the areas, leading to girls missing school or dropping out altogether. With the improved Sampoorna machines there will be more opportunity and reason to talk about menstruation and everything it entails. This is a great start in breaking the taboos and so allowing the girls to get an education and a future.

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Table of contents

1. Introduction

1.1 Problem statement

The product this graduation project is about is called “Sampoorna”, which is derived from the Sanskrit word for *complete* or *abundant*. It is set up by a company called EcoDev Solutions, locally based in Calcutta, India. The Sampoorna project consists of two machines: a vending machine and an incinerator, which are set up in schools in rural areas of India (EcoDev Solutions, 2015). Shortly said, the vending machine provides the girls in each school with affordable sanitary napkins, while the incinerator is where the girls are meant to dispose of their old sanitary pad safely. The Sampoorna machines are still relatively new, which means that certain desirable functions are not yet implemented. One of these functions is the connection between the two machines.

The connection between the machines will help the social workers and other people involved with collecting data on how many sanitary napkins were sold and how many sanitary napkins were disposed of after, for example. Both machines should therefore keep track of what is happening, when something is happening, etc. Ideally, the social workers would know which girl was responsible for which specific purchase or disposal. This would allow them to make sure each girl gets the care she needs, and when something seems to go wrong or be unclear, the social worker can step in to help the girl in time. It can therefore be said that the problem lies in the lack of connection between the two machines and data not being kept track of (Rana, personal communication, March 30, 2018).

This graduation project is only one out of four projects that were made available through the company EcoDev Solutions. Out of the other three options one more will be turned into a graduation project, which entails improving the user interface of the vending machine. Therefore it is very possible that there will be similarities in background context, for example, between this report and the one written by Emma Boersma. Some communication with EcoDev Solutions is done together, which means that the same questions were asked and the same answers were received. On top of that the same evaluation group of Indian women was questioned (as will be discussed in Section 6) and there were several meetings throughout the semester to update each other on what was being done. These meetings made sure that the solution for an individual problem did not obstruct (part of) the other’s project.

1.2 Goal

The goal of this project is to make sure that both machines can keep track of some data and are connected to the other in some way. In an ideal situation, both machines would be able to connect personal information to the data as well. This information then needs to be accessible to social workers that work with the girls in that particular school (Rana, personal communication, March 30, 2018). There are a lot of restrictions and issues that need to be considered when designing for this particular goal, think about privacy issues or electricity limits for example, but these will be dealt with throughout this report. The most important part in all of this is that the connection between the machines and the social workers should work in a reliable way and give valuable, reliable information.

1.3 Research question

The problem statement and goal result in a research question that this project is based upon. This question is: What is the best way to connect both parts of the Sampoorna project to each other and keep track of interesting (personal) data to send to the social workers. There are multiple sub questions that will make answering this main question easier by splitting it up in parts. These questions are:

- How can the machines be connected to each other and the social workers?
- How can the machines keep track of personal, interesting data?
- How can this data be sent to the social workers?
- How can personal, identifiable information be connected to the data?

1.4 Report outline

The goal of this report is to answer the research question as well as possible. In order to do this, first the background context will be given to get a good understanding of the situation. Also related work, literature and other research will be discussed. Then the ideation phase will be described to show how the final solution was reached. This solution will be specified in the section following that: the specification section. Here the final solution will be written down in more detail, such as colour or price. The realization phase after that is section 5. Here sketches and prototypes are made and explained. Section 6 describes the evaluation of the prototypes by two different evaluation groups. The discussion phase can be found in Section 7, where alternatives and future recommendations are discussed. Section 8 will detail the conclusions and have a summary of the answer to the research question, for example. At the very end of the report references used and appendices can be found.

2. Context analysis

2.1 Background analysis

In the following pages multiple causes will be researched on why adolescent girls in rural India start missing school as they get older. It is universally known that education is very important for any child's future. This is not only the case in the Netherlands, but also in other countries, such as India. Even though India is becoming a more and more modern and developed country, rural India is still behind. Research done by the Nielsen Group together with Plan India (2010) (as cited in Van Eijk et al., 2016) shows that a lot of young girls miss about 50 days a year of school. Between the ages of 12 and 18 more and more girls start missing schooldays. Sinhai (2010) and the Nielson Group (2011) confirm that the main reason is the start of their menstruation cycle. A lot of the girls that miss school either do not know how to use or cannot afford sanitary napkins.

The AC Nielsen Group together with Plan India (2010) (as cited in Van Eijk et al., 2016) found that 23% of girls in rural India quit school altogether after their period starts. Van Eijk et al. (2016) add to this that one in four girls in the whole country miss one or more days of school monthly during their menstruation. This percentage is higher in rural areas than urban areas. According to Van Eijk et al. (2016), reasons for this absenteeism are things such as "physical discomfort or pain, lack of water, hygiene and disposal facilities in school toilets, fear of staining their clothes and restrictions imposed by relatives or teachers" (p. 6). Other things that are not related to menstruation but still affect girls going to school or not are, for instance, social background, work opportunities, village development, teacher input, parental motivation, etc. (Drèze & Kingdon, 1999). So while the problem sounds simple, girls are missing school, there are multiple causes that make it complicated.

The eventual objective of this background research is to find out what the situation, related to menstruation, is like in rural India for these girls. The analysis will take multiple sub questions and go into detail about each one in turn. The sub questions are about rural India's general level of technology, the sanitation for women, what communication is like on the topic of menstruation and what girls use for their periods. The situation is very different in India as compared to Western countries, which is why extensive research is needed (Routray, Torondel, Clasen & Schmidt, 2017). The answers to all these questions combined will result in a good summary of the relevant situation in rural India. This in turn will lead to a better understanding of why girls miss or drop out of school. Understanding the problem will give a better answer to the problem and background research's main question. Therefore, this background research's main question will be: What are the surroundings and experiences like for teenage girls in rural India in early stages of menstruation.

2.1.1 Technology and sanitation

Technology in (rural) India has slowly but surely improved over the past decade, but differences between groups are still present. Cecchini and Scott (2010) start by saying technology in India used to be mostly focused on agriculture. Nowadays, however, other uses have started to emerge too, even in rural India. People have become more aware of the importance of hygiene, which resulted in things like incinerators being placed in public places (Goyal, 2016). Even though progress has been made, unfortunately the differences between groups are still big. While the richer people, usually located in urban areas, have started using things like smartphones, the poorer people, who are more present in rural India, still communicate face-to-face most. Problems with internet connections and/or electricity make this gap even bigger (Goyal, 2016). Cecchini and Scott (2010) go on about this by saying these struggles make advancing with ICT projects difficult for people in those regions. Their research

shows that computers are only present in 12% of the rural homes and are always shared. Telephones are more present, namely in 63.3% of the cases. This all shows that while there are still differences between rich and poor, and rural and urban areas, there are a lot of modernising movements throughout the country.

Sanitation in rural areas still leaves lots to be desired too with, for instance, unsatisfactory restroom facilities especially concerning menstruation. As is shown by Routray et al. (2017), even though provision of water, sanitation and hygiene facilities would make the life of female adolescents in rural India much safer and healthier, relatively little is done to actually make progress in that area. Defecating in the open is very common in India and menstrual hygiene is not valued by society in general. This is confirmed by a study by Garg, Goyal and Gupta (2011). Fortunately, some slight progress has been made over the past few years. For example, the new government in 2010 made toilet construction mandatory for schools (Sinhai, 2011; Routray, Schmidt, Boisson, Clasen, & Jenkins, 2015). In the same year they made progress on menstrual hygiene too. A new plan for subsidised sanitary napkin disposal in rural areas should prevent health problems and educate young girls about their menstruation, as is said by Garg et al. (2011). More about sanitary napkins will follow later in this paper. Some progress has been made, but there is still room for improvement in the area of sanitation.

Smartphones are not really common in rural India, although even there it is on the rise. The lack of or bad 3G and/or 4G infrastructure makes it harder and less interesting to start using a smartphone in that area now. This is because a lot of functions that make a smartphone an actual smartphone require internet, such as downloading and using a lot of apps (Watkins, Kitner & Mehta, 2012). In urban areas smartphones are relatively common. A study on smartphone usage done by Watkins, Kitner and Mehta in 2012 revealed that mobile phones can be especially helpful for young women. Using a smartphone helps them contact friends and family easily whenever needed, allows them to meet new people and keep in touch with these people. It also lets them stay out later, which allows them to stay in school longer and relieves (male) relatives of having to always take them everywhere. So, while smartphones are not as common in rural India as other regions, there would be advantages for people living there too.

2.1.2 Communicating and misconceptions about menstruation and sanitary napkins

Talking about menstruation is generally considered a taboo in (rural) India, making it hard for girls to know anything about it by the time it begins. In these paragraphs, first something will be said about this lack of communication, after that some misconceptions and restrictions will be discussed, and finally sanitary napkins will be mentioned as well. As was said in a previous paragraph, having a smartphone allows young women to speak to other young women. Seeing that for them it can be embarrassing or difficult to talk about sensitive topics with someone else face-to-face, this anonymous environment is a good solution (Watkins et al., 2012). Menstruation is one of those sensitive topics. As the study by AC Nielsen and Plan India (2011) showed, mothers have a hard time informing their daughters about menstruation, even though they do want to. Talking about it is already a taboo, which leads to the topic being avoided and a lot of girls not knowing anything about menstruation as their first period starts. A study done by Dasgupta and Sarkar confirmed what AC Nielsen and Plan India (2010) described in their study. The study by Dasgupta and Sarkar showed that in a secondary school with 160 girls, only 108 girls were aware about anything about menstruation before their first period. Only 60 of them learned anything about it from their mother, 46 others learned about it from a friend. This shows that discussions between peers are limited, but important.

A lot of misconceptions concerning menstruation are still present in modern-day rural India too. The same study done by Dasgupta and Sarkar that was mentioned in the previous

paragraph also showed that only 138 out of 160 girls (86,25%) were aware of menstruation being a physiological mechanism. Others believed it was either a curse, disease or a result of a sin. Even more shockingly, only 4 girls knew the source of the bleeding. The summarising, overarching study done by Van Eijk et al. (2016) shows a slightly more positive view on this, where they found that about a quarter of the 97070 questioned girls knew about the source of bleeding. Deep-rooted taboos and myths are at least part of the cause of these misconceptions, seeing that they make (talking about) menstruation out to be shameful, gross and weird (Goyal, 2016). When menstruating, girls are restricted in a lot of areas because of these taboos. George (2017) gives examples of them being restricted in visiting religious ceremonies, their diet and cooking, washing themselves and their clothes, etc. which does not help with their mental or physical health at all. These claims are reaffirmed by Van Eijk et al. (2016). Summarizing this, it can be said that there are there are misconceptions about the source of the bleeding, for example, and that the girls are restricted from various regular, daily activities.

Sanitary napkins would improve the situation of adolescent girls because of various reasons. Routray et al. (2017) as well as Dasgupta and Sarkar (2008) say that using sanitary pads can prevent health issues and make it easier for the girls to go to and stay in school, for example. Right now, girls in rural India are not always aware of the existence of sanitary napkins. Multiple studies show that generally speaking half the girls in rural India have never even heard of sanitary napkins and, even if they did, they do not use them (Dasgupta & Sarkar, 2008; Thakre, S. B., Thakre, S. S., Ughade, & Thakre, A. D., 2012; Nielsen Group & Plan India, 2010). According to Thakre et al., only about 30,8% of rural girls used them, compared to about 60,6% of girls in urban areas. Current most-used alternatives include, but are not limited to, new and/or re-used cloth, ashes, sand, etc. According to Sinhai (2011), these alternatives make RTI's (Reproductive Tract Infections) much more common for these women than should be necessary. The reasons for preferring cloth are mainly the cost and availability of sanitary napkins. AC Nielsen and Plan India (2011) add to this that most of the girls reuse the cloth multiple times and tend to neglect washing it. Use of sanitary napkins in rural India is limited due to cost, availability and ignorance, but could, for example, have health benefits for the local girls.

2.1.3 Conclusion

From what is written above, it can be concluded that the situation in rural India is far from ideal for adolescent girls. This background research's main question was: What are the surroundings and experiences like for teenage girls in rural India in early stages of menstruation. This question can be answered in parts. The technology in rural India has been improving, especially over the last few years. The differences between urban and rural India, however, are still very big. Limited access to electricity or internet connections make this gap even bigger. It also makes it more difficult for the smartphone to be widely used in rural India, even though its use is on the rise. Using a smartphone could be helpful for adolescent girls in multiple ways, but the main advantage is that they can have an anonymous platform to share ideas and discuss things with other girls. In this case it could be their menstrual cycle, for instance. Sanitation has also not improved tremendously over the past few years, mainly because the general public does not see a need for it.

Talking anonymously with other girls could be exceptionally useful because of the deep-rooted taboos that are still present around menstruation in rural India. Having your period is perceived as weird, dirty and shameful. This makes it hard for a lot of girls to talk about it with other people, even their mother. Not talking about it keeps these taboos in place and keeps the girls ignorant about everything surrounding their menstruation. About two-thirds of the girls in rural India do not know anything about menstruation before their first period starts, only a

quarter of them knows that the blood comes from their uterus, and only a third uses sanitary pads on a regular basis. The biggest problems for the usage of sanitary napkins are the relatively high cost, ignorance on the topic and a limited availability. Taking all this in account, it can be said that the surroundings and experiences of teenage girls in their early stage of menstruation in rural India are improving, but still not very positive due to a lack of communication and awareness. Technology, sanitation and hygiene are still behind compared to the rest of the country and parts of the rest of the world, which is also keeping the options for improvement for young girls limited.

In order to answer the aforementioned main question better, more variables could be taken into account, although the most important things have been discussed. Other things that influence the situation of young girls are, for example, the favouritism of boys, the old caste system and local teachers/social workers. Fortunately for the girls, the situation is still improving, but this does mean that every few years the situation changes. This, too, makes it necessary to do new, updated research after a while to make sure the research is still relevant at a later time. For the scope of this project the socioeconomic context of rural India is clear enough. Some more information will follow in the literature review and state of the art, but the most important aspects of the culture and local situation have been mentioned.

2.2 Literature review

As was mentioned in Chapter 1, the aim of this graduation project is to find an answer to the following research question: What is the best way to connect both parts of the Sampoorna project to each other and keep track of interesting (personal) data to send to the social workers. In order to come to a good answer, a few sub questions were mentioned as well. The available literature about these sub questions will all be treated in turn throughout this literature review. For the sake of completeness, the four sub questions mentioned in Chapter 1.3 will be written down again in this section. They are as follows:

- How can the machines be connected to each other and the social workers?
- How can the machines keep track of personal, interesting data?
- How can this data be sent to the social workers?
- Ideally, how can personal, identifiable information be connected to the data?

A literature review (and later a state of the art) loosely based around these sub questions will follow in order to see what knowledge is already available concerning the goals of this graduation project.

2.2.1 Social workers and technology

Connecting technology and social workers in order to improve the work and care is not a new concept. According to Our Lady of the Lake University (OLLU, n.d.), social workers use technology in multiple ways. Technology is very useful for taking, storing and sending clients' notes, for example, or doing research or business operations. While there are therefore advantages to working with technology, there are also disadvantages. A good example is that social workers always have to protect their clients' privacy and have to handle all their records confidentially and with care. They have to be able to protect everything from somehow being leaked through a security breach, but also against system failures or a computer crashing (OLLU, n.d.). Knight (2017) adds to this by saying that consent is also a very important aspect to keep in mind when social workers are collecting and storing potentially sensitive data. Most organisations have their own Code of Ethics, which should prevent major issues from arising and give a certain guidance to the employees or volunteers (OLLU, n.d.). More about privacy in India will be said later in the literature review. In the Sampoorna machine, it is necessary to

consider that there are both advantages and disadvantages to social workers in working with technology.

Working with a vulnerable group of people, in this case young girls in rural India, adds another layer that has to be considered. De Silva et al. (2005) put it in the following way:

> *"Social workers should be aware of the cultural contexts (…) This requires the continuous development of specialized knowledge and understanding of the history, traditions, values, family systems, and artistic expressions of major client groups served through technology (…) Because of the social isolation often experienced by people in vulnerable populations, social workers should be aware of the potential for exploitation and misuse of electronic methods with these individuals and families" (pp 6-7).*

With this De Silva et al. (2005) are saying that it is easy to misinterpret or misuse the knowledge social workers have of these individuals. Machines generally have no idea of cultural values, for instance, which is why it is important that the people involved with them, such as social workers, make sure that they are appropriate. With appropriate not only culturally appropriate is important, but also that the machinery is easy to understand, for example (De Silva et al.). Thompson (n.d.) adds to this that social workers should be considerate in whether their mode of communication is appropriate to the group. Seeing that in this case accessing the internet on a regular basis is something rural girls struggle with, social workers should either help them or use another way to communicate (Thompson, n.d.; Watkins, Kitner & Mehta, 2012). Parallel to the social workers' responsibility towards their clients, the developers of the machine and its functions are responsible for making sure that the machinery is appropriate for use by the social workers involved.

2.2.2 Personally identifiable information and privacy issues

Personally identifiable information is a broad term that brings a lot of privacy issues with it that will be discussed in this section. What makes it a broad, somewhat vague term is the fact that there is not really a uniform definition of personally identifiable information (PII) available (Schwartz & Solove, 2011). As Schwartz and Solove (2011) point out, even so-called de-identified data can be retraced to the original person involved. Narayanan and Shmatikov (2010) agree with this by saying "Any information that distinguishes one person from another can be used for re-identifying data" (p 24). Even though saved data may only include a person's age, favourite candy and zip code, it might still be retraced when it gets linked to some other source or sources of data. This is mainly what makes it hard to say which data gets classified as PII and which does not.

In the case of this graduation project the personally identifiable information is fairly sensitive. Ideally, it will contain information about who buys what at what date and time, for example (Rana, personal communication, March 30, 2018). This information is saved and looked into by social workers if needed, in order to make sure all is going well with the girl concerned. This is not a bad thing in itself, but if the data somehow ends up in the open the consequences can be negative for the girls (Rana, personal communication, March 30, 2018). Protecting this sensitive data is therefore definitely important to look into while working on this project.

Research shows that there are several ways to protect PII and other private data. One technique that is mentioned a lot is de-identifying data (Narayanan & Shmatikov, 2010; Schwartz and Solove, 2011). This is done by taking out information such as a name and changing it into a unique number, for example. However, as Narayanan and Shmatikov (2010) point out, it is not a method that makes the data completely untraceable. Friedman and Hoffman (2008) add to this by saying that while both mobile and non-mobile systems are subjected to a lot of similar

security threats, non-mobile systems are usually better protected. The reason for this is that non-mobile systems are more likely to be "protected by corporate firewalls and other security measures located at the corporate perimeter, such as intrusion Prevention Systems (IPS) and virus scanning systems. Mobile systems, in contrast, connect to the Internet or shared networks directly, bypassing the corporate defences" (Friedman & Hoffman, 2008, p 160). Therefore it can be said that using a desktop program instead of a mobile application already helps with securing data. Some other defences against security and privacy breaches are, for instance, education, (data) encryption, identity and access management, etc. (Friedman & Hoffman, 2008). All these different (combinations of) ways to protect data and privacy should make it possible to protect the PII in the Sampoorna machines.

There are both similarities and differences in protecting personally identifiable information and privacy in India as compared to the western world. Generally speaking, people in India are less aware of privacy issues and feel less concerned about them as well (Kumaraguru & Cranor, 2006). The same study revealed that 14% of Indian internet users always felt comfortable to share their phone number online, compared to 2% of Americans, and 29% always felt comfortable sharing their health and medical history, compared to 6% of Americans. This shows that educating local social workers on the topic can prove to be very important to make them aware of the risks. It is important to make sure that in the education and the system itself article 21 of India's constitution is considered. A recent court case ruled that privacy is now a fundamental right in India, based on this article, which says that "no person can be deprived of their life or liberty without a procedure established by the law" (Safi, 2017). Safi claims this case is only the start of the rise of privacy as a right changing ways of thinking and acting in India. It can be said that while people in India used to not worry about their (online) privacy a lot, things have started changing in the last few years.

2.2.3 Sending information from one place to another

There are multiple ways to send data from one place to another, such as from a vending machine to a computer. The internet is nowadays probably the most obvious and most-chosen one. Vending machines with a network connection have already been installed in various countries and regions, such as the smart vending machines made by Coca Cola. Razani (2016) discusses this example starting with the extra options the new machines now have. Because each machine has their own IP (Internet Protocol) address, Coke can now "identify each individual machine, keep track of inventory, conduct real-time test marketing and monitor trends and drinking preferences, adjusting selections accordingly" (Razani, 2016). Intel (2016) had a study of their own that confirmed that smart vending machines could be used for inventory and maintenance, which could both turn out to be interesting for the Sampoorna machines.

Storing data "in the cloud" is a phrase that is heard more and more often these days. The study by Intel (2016) involved a very basic vending machine prototype. In this prototype, the Microsoft Azure cloud was accessed through the Node.js software that is widely available on the internet for free (Node.js, 2018). This cloud can then, in this case, be used to exchange information with the administration applications. This information can be what is dispensed and when, for example (Intel, 2016). More about this machine will also be discussed in Section 2.3, the State of the Art. According to Ananthanarayanan et al. (2009), cloud computing enables the end-users to use supercomputing power when they need it without the need for extensive infrastructure and managing. According to this research, cloud computing for lots of data should entail the following:

"The underlying architecture for cloud computing typically comprises of large distributed clusters of low-cost servers in concert with a server virtualization layer and parallel programming libraries. One of the key infrastructure elements of the cloud stack, for data analytics applications, is a storage layer designed to support the following features: (1) scalable – to store petabytes of data, (2) highly reliable – to handle frequently-occurring failures in large systems, (3) low-cost – to maintain the economics of cloud computing, and (4) efficient – to best utilize the compute, network and disk resources" (p1).

The Intel research (2016) mentioned before confirms the added value of cloud computing that they also recommend for the use in smart vending machines. All in all, cloud computing and using a network connection are well-researched techniques with a lot of options related to the Sampoorna machines.

2.2.4 Conclusion

From what was written above, some recommendations can be made towards the answer of the initial research question: What is the best way to connect both parts of the Sampoorna project to each other and keep track of interesting (personal) data to send to the social workers. The literature review showed that social workers are accustomed to working with some technology, but this kind may be new to them. In order to make sure that the technology of storing and handling data is used in an appropriate, safe and secure way educating the social workers may be necessary. As long as the social workers are local people that know the target group, all the cultural norms, for instance, are very likely to be taken into account. While the social workers have the responsibility of making certain that the clients' data is always protected and handled with care, the developers of the technology have a responsibility of ensuring that the technology used is easy to understand and work with for the social workers.

The data the machines work with is both sensitive information as well as personally identifiable information. Because of this, privacy issues arise that have been discussed in section 2.2.2. Things such as information on names and purchases leaking might lead to negative consequences for the girls involved. Protecting privacy by securing data is therefore vital in the Sampoorna machines. Seeing that desktop devices are usually better protected than mobile devices, using the former would be a good start for this. There are more ways to protect personally identifiable information, such as: (data) encryption, education, identity and access management, etc. A good combination of these should be considered for the Sampoorna machines. What should also be considered is the fact that privacy in India is generally less valuable than in the Western world. Education, again, is vital in making sure that the dangers of having data online are understood. Recent changes in the way privacy is perceived should be followed and the system should be updated accordingly.

In order to send this information from one place to another (from a vending machine to a desktop application, most likely) multiple other things have to be thought over as well. Getting the vending machine a network access and IP address can help support keeping track of useful maintenance, inventory and purchase information for individual vending machines, for example. Storing this data through cloud computing is a widely used service. There are multiple sorts of software available that can be used to get the storing and analysing features the Sampoorna machines need. Cloud computing is already used in smart vending machines, confirming that it can be used there. All in all it can be said that there are multiple options available for both of the Sampoorna machines on how to connect, store useful data, and send interesting information to the social workers involved.

2.2.5 Ethics report

There is an extensive ethical review that details more information about privacy concerns, persuasive technology, etc. that can be found in Appendix 10.7.

2.3 State of the art

There are so far no machines that accomplish the exact same goals as the Sampoorna project is looking for. There are, however, machines that partly function in the same way. For example: there are other vending machines for sanitary pads even in India, there are smart vending machines and there are systems that collect data and connect it to personally identifiable information or a personal account. Some of these related machines that are relevant with regards to the research question will be explained in the upcoming paragraphs.

2.3.1 Smart vending machines

There are multiple vending machines already out on the market that collect data about various things that the owner deems interesting, such as inventory or maintenance for example. An example that was mentioned before is the smart vending machines made by Coca Cola (Razani, 2016). Razani mentions that Coke can identify each machine separately. This makes it easy to see and prepare for individual patterns and trends and test new drinks in places that have a specific drinking preference, for example (Razani, 2016). As Hannah Nemer (2017) says, on behalf of the Coca Cola company on its own website, the vending machines are going to be upgraded even more in the foreseeable future.

As of now, Coke is working on vending machines with AI to make the experience of buying drinks more special. The machines are connected digitally to the cloud so that they can be digitally be controlled, Nemer (2017) says. Through this, pricing can be changed by the owners and consumers can already buy from the vending machine before even reaching it. They even envision that consumers can get texts about discounts when in a train, for example, that could start a personalized chat between the consumer and a Coca Cola vending machine bot through Facebook Messenger. The bots pick up a local dialect and actually "develop a cognitive understanding of what's being said in each conversation and respond accordingly" (Nemer, 2017). When the consumer actually arrives at their destination, the drinks they ordered on the way would be waiting in the vending machine of their choice. As of now, the machines are only in New Zealand, but they should come to other countries in the next few years too (Nemer, 2017).

Another way multiple kinds of vending machines are made smart is by implementing NFC (Near Field Communication) technology. This is a way to help facilitate paying cashless at these vending machines and improves the user experience and usage in general (Kasznik, 2015). Modern vending machines can have the following small NFC logo on it  , showing which ones are compatible with cashless payments. At these vending machines a user with a modern smartphone with an NFC Chip, for instance an Android phone that runs KitKat 4.4 or higher, can now pay for their purchase through their Android Pay app (Coca Cola US, n.d.). Using NFC in vending machines is easy to use for the users and while it is not more or less expensive, it does not require them to have cash money on them (Brousell, 2012). Another advantage of NFC is that it both devices, in this case the machine and a phone, can send and receive data at the same time without needing to set up a connection first. Large amounts of data are unfortunately not suitable for NFC, as the data transfer rate is about 424 Kbits per second. Another big concern with NFC is people losing things: when a bank pass with NFC chip is lost, someone else could use the money to pay cashless without a pin (Jain & Dahiya, 2015). Fortunately there are security measures taken against this, but caution with NFC devices has to be exercised.

Figure 1: Cadbury 'Joy Generator' vending machine.[1]

A last interesting example of smart vending machines are the ones developed by Cadbury, as can be seen in Figure 1. The machine, an advertising stunt called the 'Joy Generator', got a lot of attention when it was unveiled in 2014 (Mortimer, 2014). The machine matches a flavour of chocolate to the user by examining their Facebook profile. "'The Joy Generator' lets users log in to their Facebook profile and receive their personalised flavour match which is automatically dispensed (for free), before taking a snap with their flavour in a social media enabled picture booth" (Harf, 2014). The Flavour Matcher app that is build inside the machine finds a flavour that it thinks the user would like based on the likes and interests of the current user. These could be, for instance, sport clubs, brands, charities, music etc. (Harf, 2014). Because of the free chocolate, the instant gratification, consumers were willing to share their Facebook information. According to Varma (2014), this allowed Cadbury to learn things about their customers too, but if they had asked people to rate the accuracy of the match after they could have learned more. In order to make the experience available worldwide a flavour-matching app was launched soon after (Harf, 2014).

2.3.2 Telemetry

Telemetry is defined by Boquete, Bravo, Barea and García (2002) as: "the capacity of capturing, processing and sending system data" (p1). Rouse & Winters (2005) define it a bit more clearly by saying it is: "the automatic measurement and wireless transmission of data from remote sources". They go on by explaining how it generally works:

> *"Sensors at the source measure either electrical data (such as voltage or current) or physical data (such as temperature or pressure). These measurements are converted to specific electrical voltages. A multiplexer combines the voltages, along with timing data, into a single data stream for transmission to a remote receiver. Upon reception, the data stream is separated into its original components and the data is displayed and processed according to user specifications."*

Telemetry is used often to upgrade vending machines. There are multiple companies that offer different kinds of software and hardware combinations to fit everyone's need. The most common and important improvements telemetry offers are keeping track of a machine's

[1] *Source: http://www.davidbarthe.fr/distributeur-automatique-connecte-cadbury/*

inventory and maintenance issues. Using telemetry means that certain things can be done remotely, which saves on machine downtime and unnecessarily checking up on machines that do not need attention, for example (Telemetron, n.d.).

There are different kinds of packages, so to speak, that companies offer. Televend (n.d.) offers mobile applications as well as web applications for its users. This comes with their so-called Televend Box to install in a vending machine that allows for cashless payment in multiple ways: SMS payment, QR-code payment and mobile payment. It communicates through a GSM module with the web application. It allows users to add machines or categorise them making it easy to manage. On a map the user sees their machines and their maintenance status, while on another screen the user can see how well a vending machine sells and what, for example. All of the reports can be downloaded easily by the administrator, so it can be shared when needed.

The system Telemetron offers has similarities and differences (Telemetron, n.d.). It also works with GSM communication that is securely encrypted and an added modem, as can be seen in Figure 2. The buttons all stand for different types of visits: service/maintenance, inventory loading and money collection. Pressing a button will result in a detailed report being sent to the main server and the personal online application of the owner. Another interesting extra they added to the modem is a built-in accelerometer that tells the owner if their machine gets shaken or hit. Other sensors include ones that alert the opening or closing of the door or the payment section, and a temperature sensor for storing hot or cold snacks, for example. According to Telemetron, their modems should be able to last at least five years.

Figure 2: Telemetron modem with blue buttons.[2]

Vendon is another company that offers telemetry systems (Vendon, n.d.). They focus on regular vending machines and coffee machines and work with their own “Vendon Cloud” and “vBox” systems. Their online and mobile application gives the user various summaries of their vending machines performances and allows them to filter through it easily. Similar to the previous two companies, Vendon also allows the user to follow the maintenance status of their vending machines in real time and also works with a GSM antenna in their modem. The GSM connection works over 900, 1800 or 1900 MHz, which is slightly less than Telemetron. The Vendon system has an added feature of showing the user how much money is inside their machine. For the Sampoorna machines all of these factors that have been mentioned can be considered when deciding what is best for the project.

[2] Source: http://telemetron.net/about/modem

2.3.3 Collecting (personal) data through embedded NFC tags

Using NFC in vending machines is a concept that is not new anymore, as was explained in section 2.3.1. However, there are other ways to use Near Field Communication to connect rather than just a phone or bank pass, for example. A good example of a different kind of place to put an NFC chip is the bracelet made by Wetech (Wetech, n.d.). As can be seen in Figure 3, it looks like a regular bracelet at first sight. There are, however, interesting functionalities because of the NFC tag embedded in the bracelet. As Wetech states on their website: "Near Field Communication (NFC) technology enable Wireless communication at a very short distance range. By using this technology, Wetech bracelets can interact with your Smartphone. Wetech bracelets integrate an NFC tag to communicate with your mobile´s NFC antenna" (Wetech, n.d.). Bringing the NFC tag in the bracelet close to the phone, the app will be activated. The app will than start the action that the user chose beforehand, which could be a (fake) call, sending a text, starting the camera, etc. The bracelet collects and stores the information that is programmed in it by the user, which includes personal data so that it knows which phone and app to connect to.

Figure 3: Wetech bracelet with NFC technology. [3]

Another kind of bracelets that use NFC technology are certain types of festival wristbands. Apart from being a regular wristband that shows they paid for the event, there is also a separate, usually plastic, part added to the wristband with an embedded NFC tag. Wristbands like this can be seen in Figure 4. "One of its main advantages, and what makes it perfect for festivals, is that data stored on a passive card/chip is activated using the power of the active device (when in close proximity)" (Oveit, n.d.). The chip, encrypted with SSL certificates, made by Oveit can be charged with money from a user's PayPal account, for example. The user can then pay just by using their wristband, which saves both the user and the festival employees a lot of time paying and waiting. It also saves the users from having to carry around cash money or cards with the risk of losing them. Every chip knows who the wearer is and what kind of ticket the person bought. This way the wristband also allows them inside the matching areas on the festival grounds or restricts them based on age, for example. All the while, the wristband captures sales and interesting audience insights and demographics to report back to the organizers that allows them to improve the festival experience for the users (Oveit, n.d.).

[3] *Source: http://wetech.es/en/they-seem-magical-bracelets-with-nfc-technology/*

Figure 4: Festival wristband with NFC tag embedded in plastic.[4]

NFC tags adding to luggage tags is also something that has been done before. Tag-a-Bag is a start-up from Israel that added an NFC tag to otherwise regular-looking baggage labels that help travellers manage their trips better. Through the tags the users can "track lost luggage, access travel plans, post news of their safe arrival to friends and family via social media, receive offers and create a log of their travels" (Clark, 2012). According to the official Tag-a-Bag website, the user just downloads the app, uploads their information to the tag and attaches it to their luggage. As long as the bag is with the user, the personal information is "turned off". However, when the bag is lost, the user can turn on and share information via the app that they believe will help them find their bag, such as a phone number or reward. The finder of the bag can then touch or scan the bag with a smartphone. This way they can send the location of the bag and other useful information to the owner. Another way the tag helps the user to locate their lost bag is by allowing them to share their bag's information and a message on their social networks through the app. Which information is seen by either the finder or on social media can be customized by the owner at any time (Tag-a-Bag, n.d.).

2.4 Relevance of the research question

In the previous paragraphs it is explained what has been done and written before about the topic of this graduation project. It shows that fortunately a lot of research has already been done before that will aid the process of coming to a solution that will fit EcoDev Solutions' special requests. The fact that EcoDev developed their own, very specific machine results in an existing system not being readily available. Therefore, the research question as well as the project itself are relevant and worth answering. Parts of a solution to the research problem are present in modern day science, but the question lies in how to combine everything and how to tailor it to the special requirements the Sampoorna machines have. Tracking what purchase or disposal is done when, for example, is relevant because it helps with taking care of the girls in rural schools. Knowing what is happening is essential in order to fix what is wrong with either the machines or the way they are used.

[4] *Source: https://shhyec.en.made-in-china.com/product/hXREPUFlZWVS/China-Music-festival-E-ticket-NTAG213-NFC-woven-wristband.html*

3. Ideation

As has been mentioned before in other sections, this graduation project consists of multiple parts. There are two things that can be considered to be the main parts of the project. The first part is connecting the machines to the social workers to get interesting information to them. The second important part is connecting identifiable information of the schoolgirls to the machine so social workers know who uses that machine when, for example. For both of these parts suggestions, recommendations, answers and other ideas will be given throughout the following paragraphs based on research and interviews. First the connection between the machines will be examined, after that the connection between the girls and the machines will be reviewed. This will be done through analyses like a PACT analysis and brainstorms about different scenarios and user experiences, for example.

3.1 Connecting the machines

3.1.1 PACT-Analysis: connecting the machines

Most of the facts used in this analysis were gathered from personal communication with Dr. Subrata Rana, unless stated otherwise. A lot of facts can also be read more detailed in Section 2.1 (the Background Analysis) and Section 2.2 (the Literature Review) that were written before.

1. People

a. Social workers

The social workers are not very used to working with this kind of technology but use computers and similar systems already. They should be able to learn how to work with the technology that is needed to make the usage pattern monitoring possible, but the technology should not be too difficult. They can read and write and are able to analyse data if the information is given to them. They are invested in the system, seeing that they care at least a bit about the schoolgirls that use it and might even use it themselves. The social workers themselves are all adults that know about the local cultural and socio-economic situation. Seeing that the system will not be used very frequently, probably not every day, it should be clear. This prevents that the users will have to relearn were to find what they are looking for every time they open the system again, for example.

b. Schoolgirls

The schoolgirls are all around the same age group and do not have any physical disabilities that have to be taken into account, for example. They are a rather homogenous user group with the same cultural background too. The machine explains what the girls need to do through some written text and pictures. In order to keep the interaction time and the number of steps the girls need to do minimal, it would be ideal to refrain from adding extra interaction for them when designing the improved system. This is especially so, because a girl only uses the machines for one week every month. When designing for the girls all the taboos that surround menstruation should be considered, seeing that they play a role in how and when and why the girls do or do not interact with the machines. This emphasises the need to protect their privacy when working with data that concerns them.

2. Activities

The eventual goal of the usage pattern monitoring is that social workers can see what parts of the machines are misunderstood or if girls need more help otherwise. To get to this goal, the social workers should get information that is send from both the machines that are in their school, but not the machines in other places. The data should be collected regularly, so that the information the social workers have is up to date. Sending the data once every day should

potentially be enough, but could be increased when tests show it is not enough. Social workers should be able to work with the information individually and schoolgirls should be able to still use the machines without help from others. It should not turn out that the machines give the social workers more work, but rather help them with current problems they face. Therefore, apart from the social workers having to analyse the data themselves, the tasks are mostly passive. This means that the users do not need to help the machines much to get to the goal, but that the machine will do most of the work itself. Sending data from one place to another, most likely a desktop application that could be used and accessed by social workers, should be done automatically instead of manually. Data input by the schoolgirls as well as the social workers should be limited.

3. Context

The environment the incinerator and the vending machine are placed in are usually the same. They do not necessarily have to be in the same room, but in most cases they are. They are placed inside a public building and mounted securely to the wall. They are usually placed in or nearby a toilet but are still kept dry. The circumstances under which activities with the machines happen are usually pressure-free. The girls have enough time to do what they need to do to get to their intended goal, the tasks are not very difficult, and the tasks do not require a lot of concentration. The machines are used during school hours or a little bit after that, but when the schools are closed they are on stand-by, so to speak. This would be a good time to update the social workers' information, seeing that there are a few hours in which nothing happens with the machines. The machines or data/information will not be accessed from home or another place, they do not have to be mobile. Organisationally speaking, adding a usage pattern monitoring part to the machine should not lead to jobs lost or gained. It does, however, change the "job description" of the social worker that is already there. The new skills the social worker needs are not very extensive, but parts of the system should be explained. The social workers should be able to find what they are looking for easily, but should also be made aware that the data they are dealing with is sensitive and should be handled with care.

4. Technologies

Input data for the program will be gotten from the vending machine and the incinerator. Sensors will register what happens with the machines. Think of, for instance, sensors that know how many sanitary napkins are still in the machine or sensors that can count how many times the incinerator is used that day. The machines will then send this data to the social workers' computers via the internet or Bluetooth, for instance. The output this will show is gathered data and most of the data will be numbers. In order to keep the output understandable for the social workers there should also be a short explanation about what the data is. Which machine is sending it, for instance, or times that are added to show when what happened. The program for the social workers is "dial in" rather than it always being on. When the user opens the program the data is shown, but if the program is not opened the data will just be saved in a secure location. Every day at a set time the data will be updated, but the updated data will only be shown in the system after starting it up again after this time. The graphic user interface (GUI) should be clean and easy to use. There is no need to make the system fun or especially interesting to use, seeing that the system is just meant to provide information quickly and easily. More options, colours or buttons will only unnecessarily complicate the system.

3.1.2 Possible scenarios for the machines

There are multiple ways to transfer information from one place to another, or in this case from one or multiple machines to the social worker. The six scenarios that were chosen are depicted in Figure 5. In this simplified sketch you can see the incinerator and vending machine

depicted as coloured squares, the social worker as a blue circle and a newly introduced machine or system as a red rectangle. The arrows between different parts indicate where the information is coming from and where it is sent to. In every scenario the eventual goal is for the social worker to have the interesting data from both machines.

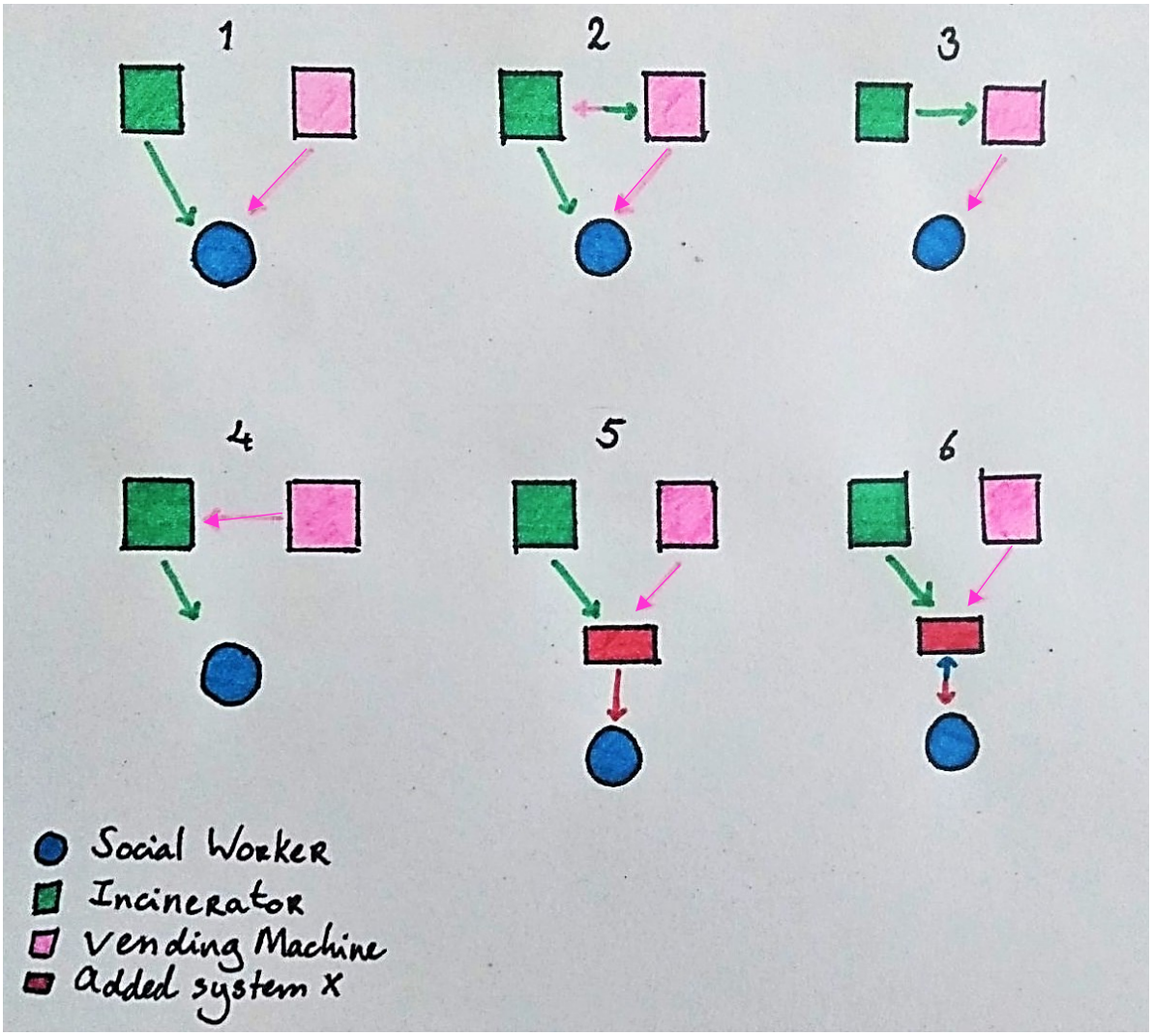

Figure 5: 6 Possible scenarios for transferring information

In the first scenario the machines are both sending information to the social worker('s computer application). In scenario 2 you can see the same thing happening, but in the meantime the machines are also communicating with each other. In scenario 3 and 4 this is not happening anymore. In these cases a "master and slave" situation is drawn, meaning that one slave machine always reports to the other master system. The master then sends the data to the social worker, meaning that only two connection links will have to be made. In the fifth and sixth scenarios another system is added to the circuit. This system can save and store the information of both machines as a link in between and then send it to the social worker. In the sixth scenario the social worker can also send information to the system so that they can change information about a machine, for example. In scenarios 5 and 6 an extra connection could be added between the vending machine and the incinerator, but this is not done because this option will be discussed through other scenarios.

3.1.2.1 Conclusions scenarios

Though all of the scenarios in Figure 5 are options, some of them will work better than others in the context of this project and the Sampoorna machines. Scenario one would work well in this case, because it is simple and straightforward. There are not a lot of connections that have to be made and the social worker gets all the information they need. Scenario 3 and 4 also work well because of these reasons. Now the machines do depend on each other more than in the first case, however. If one of the machines fails in scenario 1 the other will still send the information. If the incinerator fails in case 3 the vending machine might not be able to send information, but if the vending machine fails no information can be received at all even though the incinerator still works. This works in the same way but the other way around for scenario 4 of course.

In scenario 2 the machines are sending data to each other as well as to the social worker. This means that extra connections have to be established. Most of the data that is sent is, however, very likely to be similar or the same. This makes it easier to do, but in the case of the Sampoorna machines it is probably superfluous. The incinerator does not need to know any information from the vending machine to operate properly as well as the other way around. Sending the data to the social workers is enough to get to the goal of making the connection. This goal is to get interesting information about purchases, for example, to the social workers in an easy, understandable way.

In the last two scenarios of Figure 5 an extra system is added. This system can help with storing or filtering the data, for instance, if the application the social workers use is not enough. This is likely useful when a lot of (different kinds of) data are collected that make manual analysing very time-consuming. In the case of the Sampoorna projects only two machines are collected that send a reasonable amount of data, which should make it doable for a computer application to handle. If in the future there is need for a way to connect multiple machines in a district, for example, it might be useful and efficient to add an extra machine or system that collects, organises, analyses and stores raw data. Scenario 6 allows social workers to send information to the machines too, instead of just receiving it. This may be useful for other machines, but in the Sampoorna project changing the information that is received from the machines is not very useful.

In the current situation of the Sampoorna project that this graduation project is about only two machines per school have to be taken into account for information gathering purposes. On top of that the machines are still relatively new, so some downtime can be expected. Because of these reasons and what was discussed before scenario 1 is the recommended option for the project. Monitoring usage patterns will be done through connecting both machines to the social worker's computer application and not to each other. This will mean that the system still works for one machine if the other is not working, as they are not dependent on the other. If the Sampoorna project expands in such a way that more machines need to be connected to a single computer application, it may be useful to consider using an extra machine as depicted in scenario 5 and 6. Adding a master-slave concept such as the one in scenario 3 or 4 might help too, as this will result in less machines having to send data over longer distances. This is not applicable in the situation now, so therefore the recommendation is scenario 1.

3.1.3 Brainstorm

In order to get to the best way to connect the machines to a social worker's application a brainstorm was done. During this session a lot of different insights and options were discovered, considered and compared. The full brainstorm on paper for this section can be found in Appendix 10.1 at the end of this report.

3.1.3.1 Existing vs. new connection system

The first thing that has to be considered is whether to use an existing system made by someone else or to design and implement a new self-made system. Creating a new system has some advantages as well as disadvantages. An advantage is that it is possible to get a very specifically tailored system. The whole system will be designed especially for the Sampoorna project, so that it is adapted meticulously to the machines involved. This also means that there is no need to involve an extra party with the system. This prevents information being lost or sold, for instance, and allows EcoDev and others already involved the full control about how things happen with the machines. Making a machine tailored for the Sampoorna project also makes it easier to understand. Cultural limitations and opportunities can more easily be considered, and the system can be made specifically so that the social workers understand and enjoy what they are working with.

There are also some downsides to making and working with a new, self-made system. The most obvious one would be the potential high cost of creating it. Apart from research and building the system it should also be tested enough before it can be applied in the actual machines and be used, for example. There will be a lot of trial and error before the system works as it is supposed to do and is secure enough. There is a lot that can go wrong with a new system such as this one. All of this will also cost a lot of time, as the period of trial and error can become very long. Some copyright issues may emerge too, if code, parts, ideas or something else is used from another party. Even after the system is deemed good enough and used in the machines, maintenance will still take up a lot of time too, especially in the beginning. It will have to be done by the developers of the system, as the social workers that use the system do not have the skillset needed to take care of a complex system. For normal use of the system the social workers should not need a lot of extra knowledge if the system is fit to their needs the right way.

Using a system that already exists is also an option. Some of these systems have been shown in Section 2.3.2. There are a lot of different kinds of systems that work with connecting vending machine information to an online or desktop application that the user can access to analyse the data. Therefore it is important to know what would be required of such a system to make sure that the goals of the Sampoorna project will be reached. If the system does not work in a way that the social workers understand, for example, it is not a viable option as compared to developing a new system that does work well with the Sampoorna machines.

Throughout the brainstorm session some important requirements were written down. The first one is that the system has to comply with the standards in India. Think of, for instance, the fact that in India the frequencies 900 and 1800 MHz are widely used, while in the USA 850 and 1900 MHz are used and in Europe 900 and 2100 MHz (ESDS, 2013). This ties in with another requirement, which is that the system has to be able to connect via a good communication method that is available in rural India, such as GSM or Bluetooth. There should be little downtime and ideally this downtime should not affect the primary functions of the machines. On top of that it should work with both types of machines simultaneously (both the incinerator and the vending machine). Keeping all the relevant information in one place, using one system, makes sure it stays as easy to use as possible. The data from individual should still be easily accessible, however, to make sure that social workers know what is happening where. Seeing that computers in rural India are not very high-tech, the system should not expect a lot from the computers either. All the while it should ensure that all the data is stored securely and all the girls' privacy is guaranteed, no matter the quality of the computers or the way the machines work.

The "good communication method" that was mentioned in the previous paragraph could mean a few different things. In the brainstorm session time was spent on figuring out what is

available and viable in rural India. The report made by Capgemini and FICCI (2008) shows a few options and limitations. According to them, 2G, 3G and broadband have been on the rise for a while now in India and using them for a system such as this one is viable. GSM (Global System for Mobile Communications) is also widely used in India, while cdmaOne of WCDMA, for example, are mostly used in North and South America (Segan, 2017). This makes using GSM more interesting. Using Wi-Fi/internet, for example, on the other hand, is less likely to work in rural areas (Capgemini & FICCI, 2008; Goyal, 2016). This was also treated more elaborately in Section 2.1.1. According to Tanaya Singh (2016) Bluetooth is relatively widely used in rural India. The fact that it is an already known kind of technology makes it a good option. A last but fully different option would be using a cable to transfer information, such as USB. This would require an extra port for a cable in the machines, however, makes it hard to move a computer or machine, and requires wires that the other options do not need.

3.1.3.2 Conclusions brainstorm

Both making a new system and using a newly made one are options for the Sampoorna project. EcoDev Solutions is not specialised in this kind of software, however, so the safer option would be to pick a system made by another company that already exists. This would save time and potentially money. Creating a system specifically adapted for the Sampoorna machines will still be an option later on. Using an existing system first will allow the users and developers of the machine to figure out what parts of it work and do not work in a satisfactory way. This can then be taken into account if an own system is developed in a later stadium. To ensure that the whole system works as expected, though, a trial period should be had. If the chosen system does not meet the expectations, another one can still be chosen and tried next, seeing that there are a lot of different options.

The most important thing to keep in mind when selecting a company or brand to get the system from is the way they connect the machines to each other and the user. As was explained in detail in Section 3.1.3.1, there are several kinds of communication that work better than others in rural India. For the Sampoorna machines it would be good to find a system that either works with 2G or 3G, but not higher. 3G generally works well even in rural areas, whereas Wi-Fi and other forms of internet do not. GSM connections are used a lot everywhere in India, but if a system requires Bluetooth this is also an option. Apart from that connection it is also important that the system does not require too much power or high-tech specifications in computers, but is still able to show what happens in individual machines. Lastly, the both the connection between machines and the user's application as well as the application itself need to be very secure. The information that is transferred is private and potentially sensitive. It is vital that the data is handled and stored securely and with care.

3.2 Connecting the girls

3.2.1 PACT-Analysis: connecting the girls

A lot of information in this analysis is similar to or the same as in the PACT analysis done in section 3.1.1. Again most of the information is obtained from personal communication with Subrata Rana of EcoDev Solutions.

1. People

The schoolgirls are all around the same age group and do not have any physical disabilities that have to be considered, for example. They are a rather homogenous user group with the same cultural background too. The machine explains what the girls need to do through some written text and pictures. In order to keep the interaction time and the number of steps the girls need to do minimal, it would be ideal to refrain from adding extra interaction for them when designing the improved system. This is especially so, because a girl only uses the machines

for one week every month. The girls are also new to these kinds of technologies. As was described in Section 2.1, technology is not very well-developed in most parts of rural India, so using a tool to transfer data is very likely to be new to them. When designing for the girls all the taboos that surround menstruation should be considered, seeing that they play a role in how and when and why the girls do or do not interact with the machines. This emphasises the need to protect their privacy when working with data that concerns them. Because of taboos present in (rural) India, that have been discussed in Section 2.1, it is not-done to somehow show that a girl is menstruating in any way. Even with this, the user should be encouraged to return to the machines. It is better for their health and the environment, for example, but this is not enough incentive or not clear enough for them.

2. Activities

The eventual goal of the usage pattern monitoring is that social workers can see what parts of the machines are misunderstood or if girls need more help otherwise. This information should be received by the machine in an easy way. Mainly by not giving the girls a lot of extra actions they have to do in order to get a sanitary pad or get rid of an old one. They should be able to accomplish getting information to the machine without help from others. The users should not need to help the machine either, but rather have the machine do the collecting whatever is necessary and storing itself. Seeing that there is most likely an extra tool present to facilitate transferring the personal information to the machine, this is also an extra place that can be used for storing and other necessary actions. Data input by the schoolgirls should be limited, but this tool can be used for that. As was said before, the data will be gotten on a usually monthly basis for each girl separately, but not at the same time for all girls. The tasks are continuous, in the sense that the task will have to be redone every time but will also be started and finished each time within a few seconds. The quality is more important than the quantity here, but quantity is also important. It is vital that the data transmitted is useful, but there should also be enough data given so that the social worker knows what they are working with in the end. If the girl using a machine encounters an error, the machine should show that they have to retry using their tool to get to their goal.

3. Context

The environment the incinerator and the vending machine are placed in are usually the same. They do not necessarily have to be in the same room, but in most cases they are. They are placed inside a public building and mounted securely to the wall. They are usually placed in or nearby a toilet but are still kept dry. The extra tool used for transferring information has to be portable. This means that it will be in various environments, but most likely a bag or similar. Therefore it will be kept dry, warm and close to the user. The circumstances under which activities with the machines happen are usually pressure-free. The girls have enough time to do what they need to do to get to their intended goal, the tasks are not very difficult, and the tasks do not require a lot of concentration. The machines are used during school hours or a little bit before or after that, but when the schools are closed they are on stand-by, so to speak. Collecting the data through the tool will not take away jobs or create new jobs, as there is no-one that does it now but also no-one extra needed to handle the data. The tools have to be bought, but other than that no new funding is needed. A teacher/social worker manual that explains how the data transferring works, what has to be done and how the data is used has to be added.

4. Technologies

All the girls that use the machines need to have a personal “tool” to connect with them. They should not use someone else’s tool, as that will skew the data in the wrong direction for

both of them. It does not have to always be turned on and does not always have to be connected. The tool should only connect, “dial-in”, when the girl is really trying to connect to the machine. The personal data that is on the tool has to be put in there before or during the first use. The girl should be able to do this herself easily, so it should not contain difficult questions. Things like names and similar things can be asked. This information will then be the input. The output will be this information connected to a purchase, for example. This data can be stored in the machine for a while to send it over to the social workers for analysis later at set times. The GUI should be made easy to understand so girls know what is expected of them, especially the first time and during errors. It is useful to make the GUI interesting to the target audience to encourage them to come back to the machines to use it again. Sound may add to this experience or help with clarifying whether or not a transaction or connection was successful.

3.2.2 Brainstorm

The full brainstorm can, again, be found in Appendix 10.2 at the end of this report.

3.2.2.1 Requirements and tool options

The first part of the brainstorm consisted of requirements for the tool that is used to transmit and connect personal information during a transaction in one of the Sampoorna machines. There has to be a tool that does this. The alternative would be that girls type in the information each time, for example, which takes up a lot of time and costs them a lot more effort. Using a tool should save this time and only requires the girls to remember to bring the tool. The requirements decided for the tools during the brainstorm are as follows, but not necessarily in an order of importance. The tool should:

- Not encourage the girls to get more tools;
- Be cheap to make;
- Be big enough to support the necessary technology;
- Not be too visible/easy to hide:
    - There are still a lot of taboos surrounding menstruation and girls will not be proud to walk around showing everyone they are on their period;
- Be appropriate for a demographic group of girls around 12-16 years old;
- Be sturdy;
- Be easy to use;
- Preferably be something that is logical to bring to school;
- Not be easy to lose;
- Be portable.

All of these requirements should be considered when designing the tool. Before going into the technical specifications of the tool, it should be decided what the eventual goal is going to look like. During the brainstorm session a lot of time was spent on this too. A lot of ideas came up of varying feasibility. While almost nothing was immediately dismissed, it is easily clear that some options are more viable than others. The list of options that were considered is as follows:

- Card;
- Bracelet;
- Brooch/Pin;
- Keychain;
- Bookmark;
- Coin;
- Implant;
- Necklace;
- Wallet/Bag;

- Stuffed animal;
- Glasses;
- Pencil;
- Hair band.

A lot of these options were dismissed in the second round of the brainstorm session, so to speak. An implant, for example, is not only very expensive but also quite scary and intrusive. While a necklace and bracelet already sound better, they are actually quite "visible", which is against one of the requirements. On top of that they would either be expensive to make or flimsy, which also does not work with the requirements. Glasses and bags also have the problem of being too visible and too expensive to make for all the girls that use the machine. The keychain is small, but girls in rural areas are not very likely to bring keys everywhere. Attaching the keychain to a bag instead, for example, would make it very visible again. The hair band, bookmark and pencil got dropped for another reason, which is the fact that they are very easy to lose or lend out to someone else. The stuffed animal does not work because it is a nice "toy", so girls might either be tempted to get multiple or not want to get them at all because they feel like it is too childish.

This selection leaves the following options: card, brooch/pin and coin. In order to choose one of these three options, a table has been made with all the requirements on the left and the options on top. The plusses and minuses in the table show how fitting the option is for that specific category.

	Card	Brooch/Pin	Coin
Not encourage to get more tools	+	+/-	+
Cheap to make	++	+	++
Big enough for tech	++	+/-	+
Not too visible/easy to hide	+	+/-	++
Appropriate for target group	+	++	+
Sturdy	+	+	+
Easy to use	++	+	++
Logical to bring to school	+/-	+/-	+/-
Not easy to lose	+	+	+/-
Portable	+	+	++

Table 1: Requirements for tools versus different options

Looking at this table, depicted above this paragraph, it can be seen that every option has their strong and weak points. Some of the more important requirements are that it is not too hard to hide but still big enough for technology, and based on this the brooch/pin idea is the first to be discarded. Looking at these requirements for the other two options shows an interesting comparison. While it is easier to hide the coin than the card because of its smaller size, it is also harder to fit technology on it. The coin is also easier to lose, but more portable. On the other hand, while the card has more space to fit technology on, this also makes it bigger and therefore more easily visible.

Taking all of the options and requirements in account a decision has to be made. The biggest trade-off between the coin and the card is size for technology versus visibility. The bigger the tool is, the more technology fits on it, but the harder it is to hide it. Not a lot of technology will have to fit on the tool, however, seeing that that would make the tools expensive and more difficult to make. Because of this, it is the best option to make a tool that is bigger than

an average coin, to make it stand out from others in case it is kept in a wallet, for instance, and harder to lose. It should be smaller than an average (credit) card, however. A card has more unused space and all space that is unnecessary is actually expensive to have on this scale. The size of the coin still depends on the kind of technology that has to be incorporated to make it reach the goal of easily transmitting information from a girl to the machine used.

3.2.2.2 Technology options

During the brainstorm session technologies that could potentially be used for connecting the machines and the tools (with the personal information). NFC was already mentioned before in Section 2.3.3, for example, but there are some other options that should also be considered as alternatives. The options that were thought of during the brainstorm session are as follows:

- Bluetooth;
- The EMV chip used in a debit card;
- QR-code;
- Picture/Selfie;
- Typing a personal number;
- NFC;
- RFID.

There are multiple reasons why some of these options may work better than others. There is a very clear but important requirement that the technology has to fulfil: it has to transmit the personally identifiable information of an individual girl to the machine that is used and "attach" it to the transaction made. When this criterium is fulfilled, there are some additional requirements that would be good to have but are not necessary. These are things such as the transmitting happening instantly or as soon as possible, requiring as little steps as possible for the girls as well as the social workers, being cheap to fabricate and being easy to fix or replace in case of problems. Based on these things some options can already be discarded. For example: letting the machine take pictures of the girls using it and then trying to recognize them every time they come back is an expensive process that can go wrong easily. Facial recognition is difficult to do and because of chilling effects it may discourage the girls from using the machine.

Using a QR code to identify girls is another story. This does require the machine to have an internet connection in order to make generating QR codes affordable and easy. On top of that the machine needs a QR code reader too, in order to identify the girls later when they return with the QR code. This means that at their first time at the machine, they will generate a QR code by inputting their personal information. Through the QR code reader the machine can then later re-identify this personal information and link it to the transaction. Reading QR codes is usually done through a device with a camera that can interpret an image such as QR codes. This means that a camera and reading software have to be incorporated in the machines (Denso ADC, 2011). The reading software is especially important, because in the end the text has to be sent back to the social workers and they have to be able to work with it.

EMV chips that are used in, for instance, credit cards were also noted during the brainstorm session. They are perceived at being very secure with data (and more secure than cards with a magnetic stripe) which is an important part of this project (GUASFCU, 2015). Using EMV will quickly get very expensive, however. An EMV reader can easily cost $500, but other contactless readers can also read EMV as well as NFC, which only cost about $49 (Square, n.d.). In this case it is easier to go with NFC anyway, because it will be easier in the future to make it compatible with smartphones when those get used more in rural India.

Typing in a personal number is also an option that can be considered. This means that at their first transaction a girl needs to get a number assigned to them and fill out her personal details. In order to make sure that girls do not just fill in a random number when they access the machines that would wrongly change the data, a password or PIN should be added to it too. The number can then be printed on the tool, but the password has to be remembered. Seeing that the girls only use the machines a few times each month, however, it can become easy to forget the password. Having to type in all of these credentials each time takes a lot of time and effort, relatively speaking, which is also not an advantage.

Using Bluetooth was also considered during the brainstorm session. Bluetooth works well with larger data transfers and has a high speed for transferring data (Saha, n.d.). The range that Bluetooth has is also very large, but this is not something that is necessary or useful in the case of the Sampoorna machines. The biggest disadvantage of Bluetooth is the fact that pairing the two devices is needed (Saha, n.d.). The connection will last until after the transaction is finished, which is not useful in case of the Sampoorna machines. The girls and machines do not need to connect every time they are just in the same room, which could happen considering the range of Bluetooth.

The last two technologies on the list are NFC (Near Field Communication) and RFID (Radio Frequency Identification). They have similarities and differences that make both interesting to use to connect a girl's personal information to an interaction with one of the machines. The range of both technologies is different, for example. Whereas NFC only has a range of about 5, maybe 10, centimetres, RFID is usually able to work up until 5 metres (Saha, n.d.). Because of this, an RFID tag does not need to be directly in the line of sight of the reader. On another note, NFC tags can be set up for one- as well as two-way communication, meaning that it can both send and receive information in the same tag (Chandler, n.d.). RFID can be either active or passive. Passive tags can only be read, but active tags broadcast information and/or a signal. The active ones require their own battery, but passive ones do not (Smiley, 2016).

NFC tags can only be scanned one at a time, whereas multiple RFID tags can be read at the same time. Because of this, NFC is mostly used in payments and sharing data quickly by touching, while RFID is mainly used for tracking items and people in warehouses, airports, etc (Saha, n.d.). Lastly, as Lynn Sonya (2015) explains, while RFID used to be very widely used in the whole world, NFC is on the rise and used more and more in various situations. NFC is incorporated in most mobile phones, which might become interesting in a later stage of the Sampoorna project. The technology is also seen as reliable and is quick when it comes to scanning. People that use contactless payments in shops with their cards will be able to confirm this. Because it is so quickly readable, it helps make sure that girls involved in this project do not need to stand in front of the machines for a long time.

Considering all these various things, a choice still has to be made between the two. While RFID has a bigger range, this is not needed for the Sampoorna project. Getting a tool with the technology within a few centimetres of the machine and reader Is very viable. It might even be confusing to the machines if it reads multiple tags in a room when a transaction is made, for example. This is the main reason that NFC is deemed more suitable for this project. On top of that it would open options for smartphone use in the future and it might be interesting to look into the option of using the tag as a way to not only send but also receive information.

4. Specification

In the specification phase it is important to clarify -specify- what exactly the idea is for both connecting the information from the machines to social workers and connecting girls to the machines. They will be handled in turns again, starting with the machines and then the girls. At the end of the chapter it will also be discussed how both solutions work together in the Sampoorna machines.

4.1 Using an existing system to connect the machines

There are a lot of different kinds of machines that can connect vending machines, collect interesting data from them and send this data to the owner. Some companies and systems have already been discussed in Section 2.3.2. These systems have some similarities and some differences. Some are beneficial to the system and some have no effect on it. The systems that were mentioned in the previous section are made by the following companies: Telemetron, Televend and Vendon. Through comparing the qualities of each system the best option for the Sampoorna machines will be selected. The requirements that were mentioned in Section 3.1.3.1 that will be used to select a system are as follows. The system should be able to:

- Work with Indian standards, mainly connection frequency;
- Have a good telecommunication connection possibility;
- Be able to track inventory;
- Have low downtime;
    - This is hard to measure/hard to find, so it will not be discussed in the table.
- Need low requirements from computers;
- Work with two kinds of machines;
- Be secure both in hardware and software;
- Be able to track individual machine data.

The outcomes and estimations concerning all these requirements were put in the table underneath this text. The answers were gotten from information on every company's own website.

	Telemetron[5]	Televend[6]	Vendon[7]
Indian standards	Yes	Yes	Yes
Telecommunication	GSM	GSM	GSM
Inventory	Yes	Yes	Yes
Computer requirements	Low, multiple options for things like resolution, phone possibility, requires internet connection	Relatively high, requires good internet connection, phone possibility	Low, phone possibility, requires good internet connection
Both machines	Yes, also senses a door opening/closing	Yes	Yes
Secure	Possible SMS and/or email notifications, data only accessible by owner	Possible SMS and/or email notifications, data only accessible by owner	Automatic SMS and/or email push notifications
Individual data	Yes	Yes	Yes

Table 2: Comparing telemetry systems

[5] Source: http://telemetron.net/
[6] Source: https://televend.eu/
[7] Source: https://www.vendon.net/

Table 2 shows that the systems are generally very similar. There are some things that are not taken into account here that may make stand apart more, but they are not of interest to the Sampoorna project. Think of, for instance, the option to pay through a QR-code in the Televend machine. The fact that the systems are so similar, however, makes it relatively easy to switch from one to another if the initial choice does not work out.

In this case the first recommendation for the Sampoorna machines would be the system designed by Telemetron. It uses the 900 MHz and 1800 MHz frequencies in its GSM communication, which works with Indian standards. It does not require too much in a computer and their internet connection, but still needs one to work. The SMS and/or email notifications can be tailored to personal needs, but can also be turned off. This is good for security, seeing that automatic email notifications may be seen by other people that pass by and see a screen, have a shared email, etc. The extra option that the Telemetron system offers that makes it especially interesting compared to the other options is the fact that it has a sensor to tell when the door is opened and closed. This lets the owner know that their vending machine is being re-stocked, for example. In the case of the Sampoorna project this is especially helpful, because this can tell the social workers exactly how many times the hatch on the incinerator is opened. This tells the social workers how many times it was used that day and how many sanitary napkins where therefore disposed of. This is a very helpful part to know and the sensors in the Telemetron system can make it easy to do. Therefore the Telemetron system would be the system recommended to be used for the Sampoorna project.

4.2 The tool to connect the girls

4.2.1 The coin

As was decided in Section 3.2.2, the tool should resemble a coin, but should not be too similar so as to not cause confusion. The reference coin in this case will be a ten rupee coin, seeing that that is the biggest local rupee coin that there is and very common. The Sampoorna vending machine accepts 5 rupee and 10 rupee coins, so the girls will be familiar with it (Rana, personal file, March 13, 2018). This ten rupee coin can be seen in Figure 6. The coin is 1.8 mm thick and has a diameter of 27 mm. It weighs 7.7 grams, which is comparable to the 1 euro coin that weighs 7.5 grams with a 23.25 diameter (Numista, n.d.). The gold and silver tones are common colours for modern rupee coins and they are all round-shaped (Wikipedia, 2018).

Figure 6: A ten rupee coin from 2011[8]

[8] Source: https://en.wikipedia.org/wiki/Indian_10-rupee_coin

In order to make the tool stand out from other coins, it needs to be different from the one in Figure 6. There are multiple ways to do this, such as shape, size and colour. There are a lot of websites that let a person custom design and order their own personal coins. These are used regularly at festivals, bars, etc. There are options for ordering ones equipped with NFC as well, but these are generally relatively expensive. The cheaper option would be to order beverage coins, such as the ones in Figure 7, and NFC sticker tags in bulk. This option does, however, require some assembling. The engraving or printing of the coins can be done quite cheaply by another company, but attaching the NFC sticker to it has to be done through the Sampoorna project. There is no guarantee that the girls will understand the importance of attaching the two, so that definitely has to happen before the coins are handed out.

Figure 7: Different colours and sizes of beverage coins[9]

There are different kinds of tokens that can be ordered online. The first choice that has to be made is the material. There are options to make the tokens out of wood, metal, plastic, aluminium and more. The best material for this project would be plastic or wood. While other options may look fancier or more interesting, the tokens are not meant for showcasing or decoration. Due to the small size plastic or wood would be sturdy, still very light and cheap to get when bought in bulk. Wood can be made into shape easily with a laser cutter too. The colour should also be decided so that it matches the rest of the project. Because of the fact that both the Sampoorna vending machine and incinerator have pink details in them, as you can see in the pictures attached in Appendices 10.3 and 10.4, a pink or purple would be a good colour to get the tools made in. Making the tool a bright, odd colour is a great way to make it stand out compared to a normal coin.

The size and shape of the coin are also great options to make it stand out from regular rupees. There are companies that make tokens hexagon- or octagon-shaped, for example. Seeing that rupees are all round, as was mentioned before, these shapes would easily stand out from regular coins in a wallet, while they are still easy to hide for the girls. The downsize of this is that more difficult shapes are usually more expensive than circles. Another option would be to make the size of the tokens different from the size of rupees. The biggest rupee is the 10 rupee coin that is shown in Figure 6, which is 27mm in diameter (Numista, n.d.). Making it too small will make it too easy to lose the coins and may make it too difficult to fit NFC technology on it securely or use it at a machine. It is therefore more viable to make the tokens bigger than the rupees. Just a few millimetres will already make a good difference. It will be most clear if there is a combination of changing the size or shape of the tokens and giving them a noticeably different colour. Some example coins have to be made so that different options in colour, size, etc. can be considered more easily.

[9] Source: https://www.drinktokens.com/custom_molded_embossed_plastic_tokens.htm

4.2.2 What needs to be bought, where, and what will it cost

The tools will be made to look differently by making them out of a bright pink plastic and a size between 20 and 40mm in diameter. On top of that, the Sampoorna logo could be engraved or printed on one of the sides. This will make sure that the girls can easily find their coin even when it is put away far inside a bag, for example. There are several companies that do this that can be found on the internet. Some of them are based in India, which is a plus considering shipping costs. However, other companies not based in India also offer great services, but not all of them deliver their products in India. One Dutch company was contacted about their services in order to make some estimation. Getting 50000 35mm coins with the Sampoorna logo to India will cost, including making the coins, about €2095.- and delivery will take about a week (Salentijn, personal communication, June 7, 2018).

NFC tags should also be ordered. In case there are 50.000 coins bought, 50.000 NFC tags should be ordered too. A good website for these tags would be Smartcardfocus.com. This company is a distributor that will deliver good quality tags in bulk, making them a good price. The NTAG213 Stickers are 29mm in diameter, transparent and uses the standard 13.56 MHz frequency (Smartcardfocus, n.d.). When bought in bulk, 50000 NFC tags will cost about €20000 including shipping to India. There are also cheaper options when ordered in bulk from certain companies in China, but Smartcardfocus.com is a good option.

In order to work with the NFC tags, NFC readers should also be purchased. Because of the large volume needed, a wholesale supplier such as Aliexpress.com would be advised. There are not a lot of places that both sell NFC readers in bulk and ship to India, but AliExpress is one of them. One option would be to buy the KKmoon ACR122u NFC reader/writer that works with most NFC tags (KKmoon, n.d.). It can be attached to the technology inside a machine via USB cable, while the rectangular reader itself can be put on display on the outside, making it clear for the girls where they should hold their token. This NFC reader can be seen in Figure 8. The costs of buying 500 of these, an approximation of one for every machine (according to Dr. Rana, about 200 are already in use and more are expected), including shipping would amount to about €13000. This is about €26,- per reader. This also includes all the software that can be downloaded and used to write the needed information on the tokens the first time and read it afterwards.

Figure 8: KKmoon NFC reader with USB cable connection[10]

[10] Source: https://nl.aliexpress.com/item/NFC-ACR122U-RFID-Contactless-Smart-Reader-Writer-USB-SDK-5pcs-IC-Card/32652362261.html?spm=a2g0z.10010108.1000016.1.526565e6r3jlZG&isOrigTitle=true

5. Realization

5.1 Sketches

In order to really create a working prototype, a Sampoorna vending machine and incinerator are needed. This way the needed connections inside the machine between, for example, the NFC reader and the machine itself can be found out. Seeing that there were no machines to use, sketches are made instead with new components added, logical placements of components, etc. The sketches can be found in the figures following this paragraph with added commentary. The first sketch is the vending machine, the second one is the incinerator.

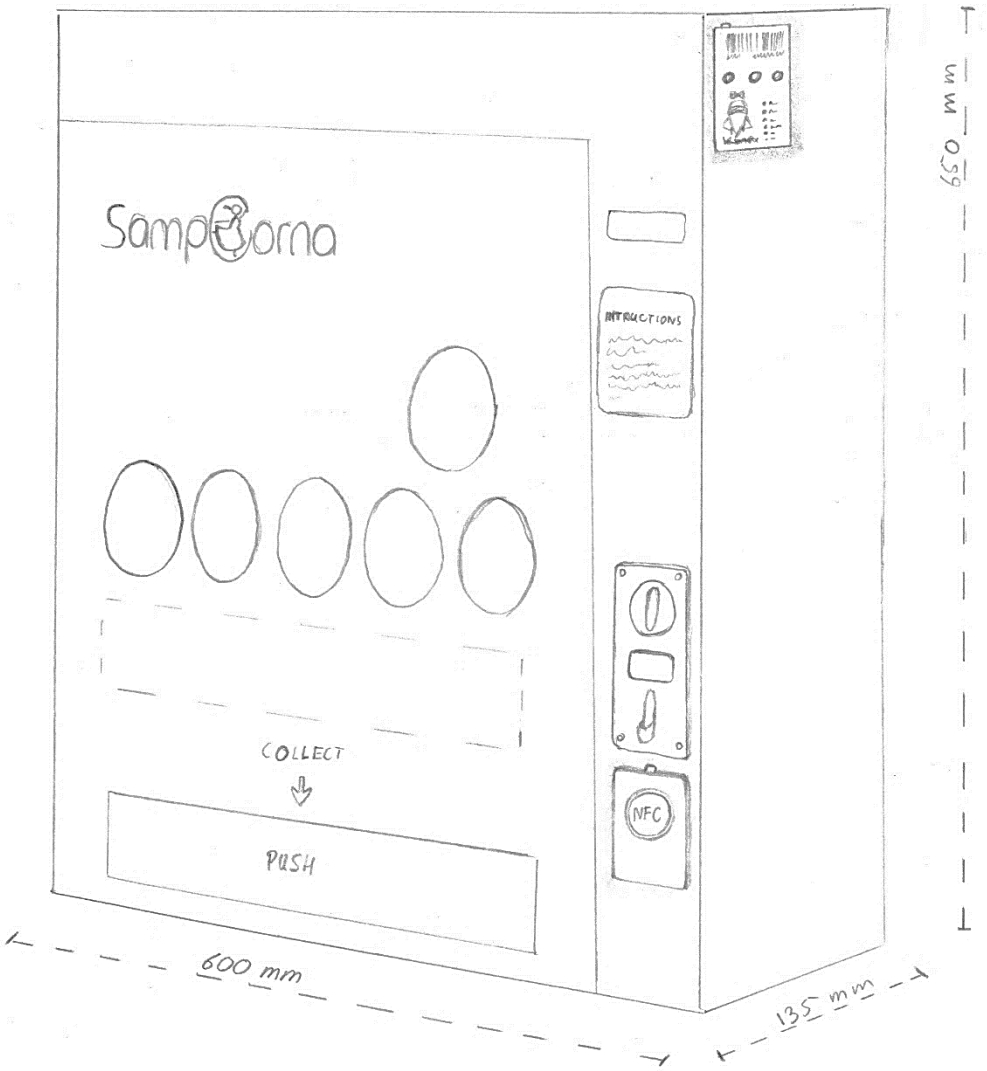

Figure 9: Sampoorna vending machine sketch

In the above sketch the dimensions of the Sampoorna vending machine are shown as well as where the new technology should be placed. This should make it easier to envision the eventual machine. The space on the left side of the machine with the six ellipses is based on what the machine looks like now. In the future, this part of the machine will be replaced with the new user interface that Emma Boersma has developed (Boersma, personal communication, June 6, 2018). The other parts of the machine will stay relatively similar to what it is now.

On the top right corner of the machine, in a real situation this would be its side, there is a new part. This is the Telemetron telemetry system. The actual modem can also be found depicted in Figure 2 in Section 2.3.2. This modem was placed on the top part of the machine as

well as the side, because this way the girls using the machine will be less tempted to tamper with the system. The top part of the Telemetron system has a small bump/protrusion, which is the antenna of the system. Next to this is the external SIM-card socket, which is not likely to be used, but should still not be tampered with by the girls. Having both of these on top also helps discourage damaging the modem.

On the bottom part of the machine, underneath the coin slot, the NFC reader was added. Unlike the Telemetron modem, this part of the machine should actually be used by the girls, so it should be placed somewhere that is logical for them to reach and see. Putting it at the bottom of the machine can help with that. Most of the vending machines are fastened to the wall on a certain height above the floor. This height is chosen so that girls can easily reach the coin slot and the "push" part where they get their sanitary napkins. Therefore putting the NFC reader on a height that is between these two parts ensures that the girls can easily reach it. Putting it underneath the part where the coins are inserted also makes sure that the girls will see it. They will need to use the coin slot to get sanitary napkins, so their attention will also go the NFC reader. The small bump on top of the reader is where the cable comes out of it. A hole will have to be made in the machine to make sure the cable can be inserted into it and connected to the rest of the machine. This hole can't be too big, seeing that girls might pull at the cord, look through the hole, etc.

Much like the vending machine in Figure 9, the sketch of the Sampoorna incinerator in Figure 10, on the next page, shows the dimensions of the machine as well as the same added new technology. In this machine, the Telemetron modem is added on the top part as well, as you can see in the top left part of the sketch. This is for the same reasons as with the vending machine before: putting it there, as much out of reach as possible, will discourage the girls using it from messing with the system in some way. It cannot be put more closely to the back, because it could be damaged when moving the machine around or fastening it to the wall.

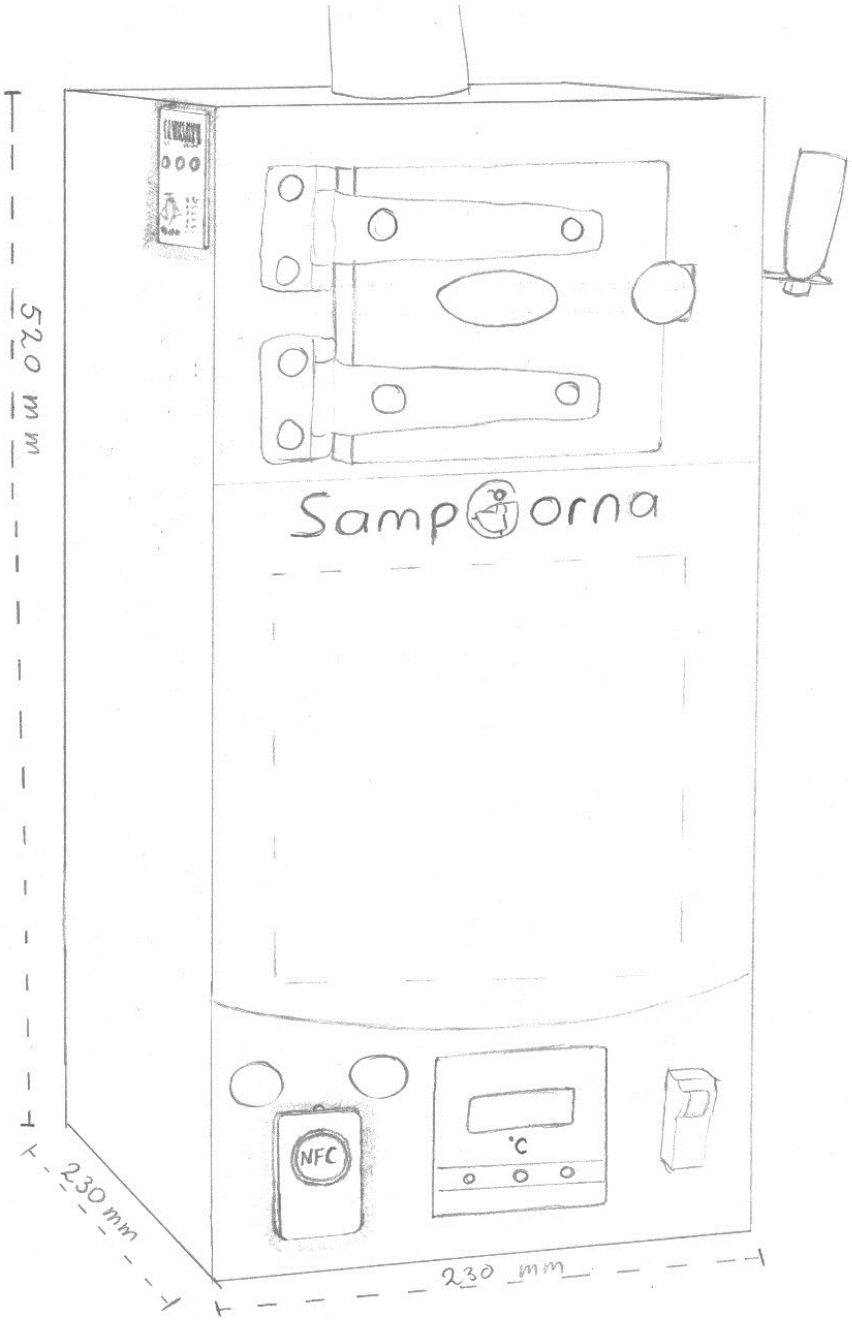

Figure 10: Sampoorna incinerator sketch

The NFC reader is attached to the bottom left side of the front of the machine, as can be seen in the lower part of the sketch. It is put underneath the red and green button, which are both reachable for the users. It would have been more logical and easy to put the reader up a little higher, seeing that the hatch for the pads is on the top part of the machine, but due to the heat behind and around the door this would not work. Putting the reader on the bottom of the machine keeps the reader itself as well as the cable away from the heat of the incinerator. The cable has to go inside the machine, which is why it needs to be away from the direct heat. It would be good to test this spot for a short while to make sure it works with the technology before installing it in all the machines.

5.2 Coin options, first prototypes

Several aspects were considered for the design of the coin, as was mentioned in Section 4.2 already too. Two materials and several colours, shapes and sizes were used to make fifteen prototypes that are to be tested in Section 6. The colours were various shades of purples and pinks, seeing that those match the colour scheme of the Sampoorna machines and are seen as girly. The shapes that were used are circles, hexagons and octagons. The sizes of the coins varied between 18 mm and 40 mm in diameter. All different coins can be found in Figure 11. For the evaluation numbers were added to the coins in order to make sure it was known which coin was meant when a comment was made. A new iteration will be done after the evaluations have taken place, after which a final prototype will be realised. The reasons these materials, sizes, colours and shapes were chosen can be found in Section 4.2.1.

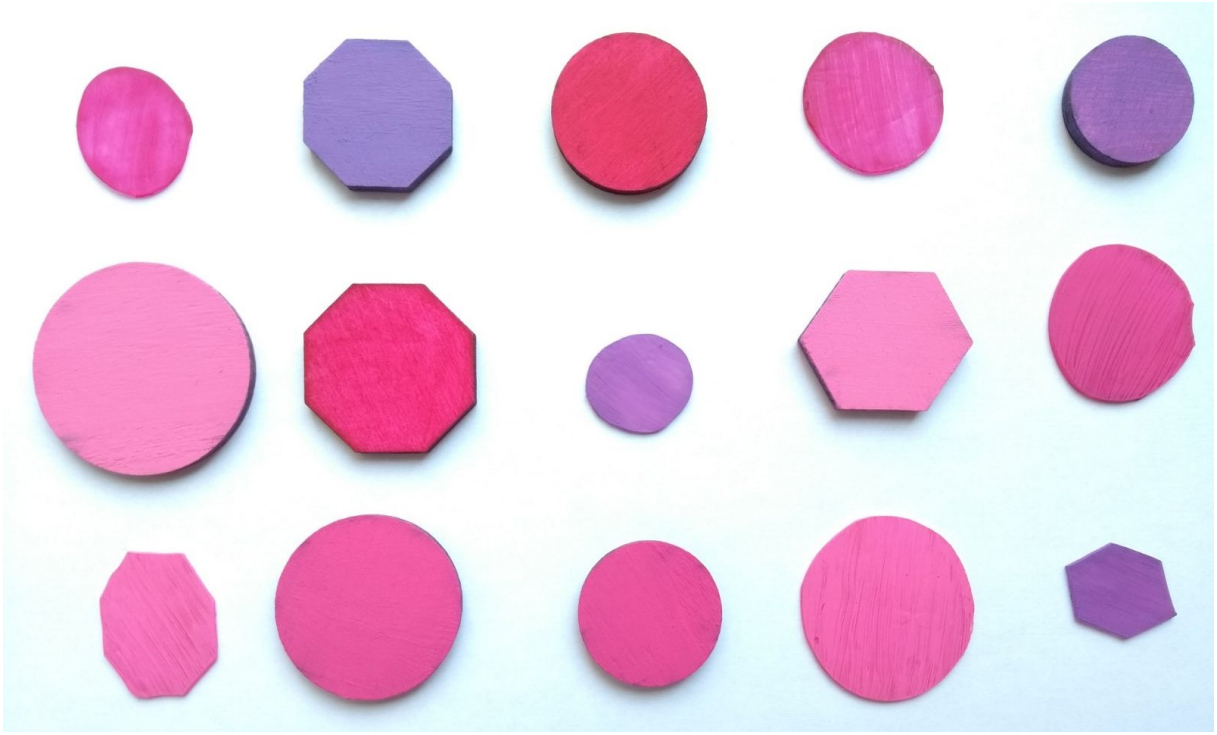

Figure 11: The 15 "prototype" coins in random order

Eight out of fifteen prototypes were made out of thin wood in the laser cutter, such as the one in the top right corner. The remaining seven were made from shrink foil plastic by hand, which makes it harder to keep the shape intact after baking it. The prototype in the top left corner is a good example of this. All prototypes were then painted by hand in pairs, so most colours are represented twice.

5.3 Final prototype after evaluation and NFC tag experiments

After the evaluations had taken place, some final choices about the coin had been made. These will be explained in Section 6.1.3 and confirmed again in Section 6.2. As a result, a final prototype was made to show a closer model of what the tool should eventually look like. Due to time constraints this prototype was made of wood, although in the evaluation section it was recommended to use plastic. The other recommendations included:

- Colour: a reddish pink;
- Size: Between 25 and 30 mm in diameter;
- Shape: Round/circle.

The final prototype can be found in Figure 12, with the side with the NFC tag facing up. The NFC tag was attached using strong glue to the wood. After this, two layers of paint were applied as well as a thin coat of varnish. The NFC tags have shown no signs of coming off after using them or taking them to various places in a wallet. The NFC tags were put in the middle of the coin for aesthetic purposes mainly, seeing that this way there will be no clear up- or downside to the coin.

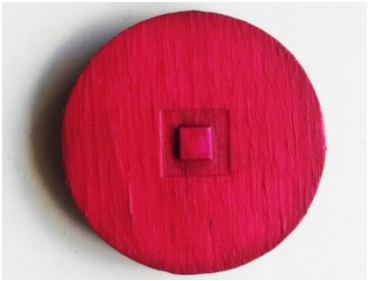

Figure 12: Final prototype with NFC tag attached

Some more experiments were done with the last prototypes. Four out of five final prototypes were made out of wood, as was said before, but the last one was made from clay. Testing this out would not only show whether or not clay would be a good alternative, but also if these NFC tags would be resistant to intense heat. The tag was baked at 110 degrees Celsius for half an hour, after which the NFC tag was still fully functional.

Out of the other four tags, two also had experiments done with them to test the durability of the NFC tags. The other tag was used as a control tag, to make sure that the NFC tags would not have become dysfunctional due to reasons other than the experimented ones. One of the test tags was submerged in water for half an hour, after which it turned out to still be fully functional as well. This would mean that even leaving it out in the rain should not result in any problems for the tag. Another tag was put underneath three kilos weight for half an hour, which would show if it would still work if it were to be put in a bag underneath books or something similarly heavy. This tag, too, was still fully functional after the test. The last tag was used for testing the effects of layers of paint and varnish over the chip. Again there were no notable changes in the usability of the tag. Even the wrong way around all tags still functioned as they did before. These experiments together prove that the final prototype is usable in the context that is to be expected for the Sampoorna project.

6. Evaluation

Evaluating the prototype and the intentions behind the graduation project was done in two separate groups. The best group of people to ask what they think of the project would be young girls that go to school in rural India, seeing that they are the main users of the machine. Due to time and financial constraints this was not feasible. Instead girls from the Indian Study Association of the University of Twente were asked to answer some questions. These girls are experienced in India's culture and schools and were more easily available. They are, however, older than the target users of the Sampoorna project are on average. In order to make up for this, another group was asked some questions as well. This group consisted of Dutch girls between 11 and 15 years old and are therefore closer in age to the people that would actually use the systems. By asking both groups questions both the Indian culture is taken into account as well as the way young girls think. There may be differences in the way Dutch girls and Indian girls think, but it is tried to make up for this by asking questions to people with both cultural backgrounds.

6.1 Girls from the Indian Student Association

6.1.1 Preparation and carrying out

The evaluation with girls from the University of Twente was more meant for investigating whether or not the ideas of this graduation project would work in their "real" environment. In order to find this out, four girls of the Indian Student Association (ISA) were each asked a few questions. The girls were contacted together with Emma Boersma, the other student doing her graduation project for EcoDev and working on the same Sampoorna machines. Therefore the same girls were asked questions for this evaluation as well as hers and similarities can be found between the two evaluations. First the evaluation for Emma Boersma's part of the Sampoorna project was done, after that the questions were asked concerning this aspect of the project. The main questions that were asked then are written down below. After this some follow up questions were asked that varied for each girl depending on their answers.

- Are there things social workers can do to support the girls in this area?
- Do you think giving social workers access to data such as who bought what from the machine, for example, helps the girls? Why?
- Do you think that someone having this data will keep a girl away from using the machine? (Chilling effects)

After this, questions were asked regarding the coin prototypes depicted in Figure 11 in Section 5.2 and again in Figure 13 after this text. The 15 coins were numbered randomly, so as to not show preference for one colour, shape, etc. but afterwards it could still be easily distinguished what was said about which coin. The coins with their numbers written on it can be found in Figure 13. The students were shown the coins in order of number, as depicted in Figure 13, starting with number 1 and ending with coin number 15. They were then asked what coin or coins they liked best at first glance and why. After that they were asked various questions about what colour, shape, material and size they preferred and why. General remarks or other different comments that the students had were written down in the "other" column. The full evaluation sheet that was used can be found in Appendix 10.5. In this table the commentary was written down by the observer/interviewer with each girl having a new evaluation sheet for her session so comments would not get mixed up. To protect privacy and anonymity the answers to the aforementioned questions were not added to this report.

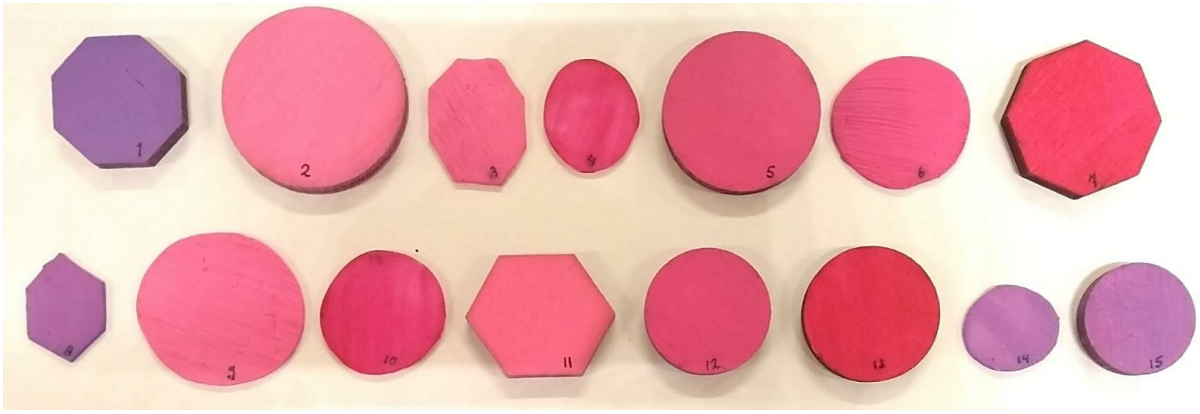

Figure 13: Coin prototypes with their numbers as used in the evaluation

6.1.2 First part: Questions on Sampoorna machine

Some interesting things have been found during first part of the evaluation process. The questions that were asked were:

- Are there things social workers can do to support the girls in this area?
- Do you think giving social workers access to data such as who bought what from the machine, for example, helps the girls? Why?
- Do you think that someone having this data will keep a girl away from using the machine?

The main thing all four girls were sure social workers could support the girls in the area with is education. Knowing the problems of an individual girl would even allow the social worker to go door-to-door with information or recommendations if the area covered is small enough. Social workers could help by giving introductory lectures in school to make the girls aware of what sanitary napkins are and how to use them, for example, or what to do with them after using them. One student mentioned that it is very likely not realistic to "take care" of everyone, but some girls need more attention than others. The Sampoorna machines and the personal data may help to narrow down the focus of the social workers and help them figure out who needs their help most.

The four students generally thought that giving social workers data on what happened in the machines would help the girls. While one was unconcerned, saying the data "can't be misused, there is no negative aspect", another was more careful and said having data like that recorded could be "daunting at first". Although it would be good to know who is shying away from the vending machine, for example. Some students concluded that it would be good to have a short informative presentation about the machines and the data they will collect at the start of the school year, for example, so the girls would know what happens to the data and how everything works. This would be better than not telling them and having them figure it out in a later stadium from some other place and getting scared or cautious. They could feel embarrassed or uncomfortable with suddenly finding out someone knew about their menstruation all along.

Generally speaking the students did not think the girls would stay away from using the machine if someone got data about their habits concerning the machines. It would, however, be good to educate them about how to use the machines and their importance, and the importance of the data tracked. Interestingly enough, two out of four students said that they believed the girls would be hesitant to use the Sampoorna machines if their social worker was male, while there would be no problem if the social worker was female. On top of that, it was important to

have educated social workers. If the social workers involved still had a mentality of girls needing to stay at home when on their period, for instance, the machines could have an opposite effect. This could be partly related to the age of the social worker too, according to one student. This all shows again how important it is to make sure that only the right people get access to the data that is collected, as was already briefly said in Section 3.1.3.1 as well as the ethics review in Appendix 10.7. Giving the data to the wrong social worker could discourage a girl from using the Sampoorna machines, according to the students questioned.

6.1.3 Second part: Prototype evaluation

For the second part of the evaluation the student was sat in front of the rows of coin prototypes shown in Figure 13. They were then asked which one they liked the most and which one they thought was the most suitable for the project that was explained to them in the first part of the evaluation. After that they were asked some more in depth questions about materials, shapes, sizes, etc. to make sure there was a complete understanding about why some prototypes would be more suitable than others.

Surprisingly enough, three out of four participants immediately said that they liked number 13 the best. Two of those also said they liked prototype 12 as well. These prototypes can be found again in Figure 14. These prototypes are both made of wood and round. Their sizes are close to each other too, with 12 being 28 mm in diameter and 13 being 30 mm. 12 is a slightly lighter but more bright pink, while 13 is a slightly darker and more reddish pink. The main reasons the girls all gave that they liked these the most were the colour and shape. One student said that the colours would "resonate well" with the girls in rural India. Another said that the size was good, because it matched the size of most Indian coins. This way it still looked like a coin and was easy to hide and disguise.

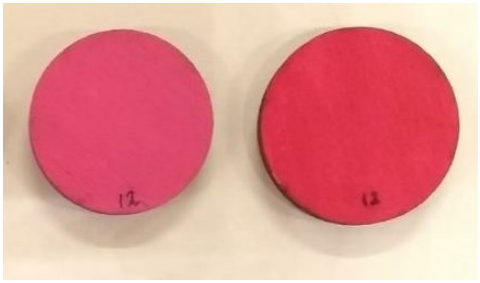

Figure 14: Prototype numbers 12 and 13

All the girls were mostly indifferent to the other pink colours. Purple however, like used in prototype 1 depicted in Figure 15, was an option for two girls while another thought it was "ugly". The shape of prototype 1 was another issue. One participant said she liked the hexagon and octagon shapes, shown in Figure 15, but another thought they were not suitable for the goal. The former girl said that a hexagon/octagon shape would be easily distinguishable in a wallet, seeing that most rupees are circles. This would make the tool easy to find for a girl even when it is in a big wallet or bag. The other opinion on this shape was that it was actually *too* easy to distinguish. If a girl would put her tool in the pocket of her pants, for instance, the shape would be easy to see from outside, meaning everyone could guess what she was carrying around. This would then lead to everyone knowing she was getting sanitary napkins and was therefore on her period. As was explained before, this should be avoided.

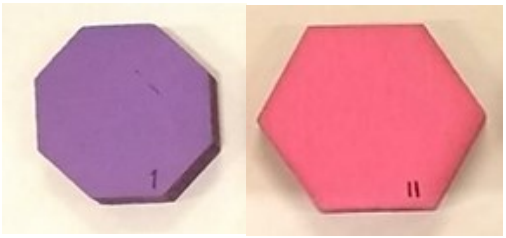

Figure 15: Prototype numbers 1 and 11

The material of the tool was discussed too. The prototypes were made from wood and plastic. Generally speaking the girls thought that the plastic was a little too thin, making it seem easy to break or lose, but that is well-solvable. There are other pros and cons to using plastic or wood. Plastic is mainly seen as flimsy and easy to lose or confuse. It is, however, easily recyclable when needed. Wood on the other hand can go bad or get soggy due to rain, but is less flimsy and feels good in the hand. One girl suggested using a wood plastic composite, which is an alternative that will be discussed in Section 7, discussion. Plastic is the main option for now, seeing that this will not splinter or go bad in the heavy rain that can be experienced in the region, although wood will still be a good alternative.

Last of all the size of the coins was discussed. Three out of four participants almost immediately said that prototype 2 was too big, which is 40 mm in diameter. Prototypes 3 and 14 were said to be too tiny, on the other hand, leading to easy loss. The coins 12, 13 and 15 were perceived as having the right size, although some said that 13 was still too big. Prototype 12 about matched the size of the Indian rupees, as was said before. Having a tool this size would be a good fit for an average wallet without being easy to lose.

All in all, this evaluation can be concluded by saying that the “ideal” prototype coin would be:

- A reddish pink, such as seen in prototypes 13 and 7;
- Between 25 and 30 mm in diameter;
- Round;
- Made of plastic, but slightly thicker than in the prototypes.

6.2 Dutch girls between 11-15 years old

In order to participate in this evaluation, a girl’s parents had to sign a consent form. This way it was made sure that both the girl and her parents knew and agreed with what would happen in the research. This consent form can be found in Appendix 10.6 at the end of this report. The girls that participated were found in a sports association that they play in together once every week, meaning that they knew each other. One week all the girls between the ages of 11 and 15 got a consent form with information to take home to their parent(s). The parents then had a week to read and sign it after which the girls handed it in again and the evaluation was held. Ten girls returned the consent form and participated in the evaluation, but for the sake of anonymity their names will not be written down. To make sure there was no conflict of interest, an independent trainer of the sports association was present at every evaluation.

After getting consent from their parents the girls were divided in groups of two or three and shown all the different coin prototypes, shown in Figure 13. The information the girls got was that the prototypes shown were meant to be used to activate a vending machine on a regular basis and would only be used by girls. They were then asked first which prototype they liked the most. After they pointed out one or two, they would be asked why that was their favourite. For completeness and to get more information on what the eventual product should

look like, varying other questions were asked after that. Their answers were collected in an evaluation form such as the one in Appendix 9.5, but unlike the girls from ISA, they did not each get their own sheet. They were then thanked for their participation and followed by the next two or three girls. Some examples of questions that were asked (in Dutch) are the following:

- Which material do you like better, wood or plastic?
- What size coin feels nice or comfortable to have in your hand?
- What size coin do you think is suitable to take with you in your wallet or bag?
- What shape do you like the most?
- What colour do you like the most?
- Etc.

The results of this evaluation lined up with the results from the previous evaluation surprisingly well. Although there were different motivations at various points due to age and a lack of context, the results were roughly similar. The Dutch girls did not, for example, make any comments about wood going bad in the rain or octagons being easily distinguishable in trouser pockets. They did, however, give a good insight in what things girls their age may like.

The colour, shape and size that were again most popular, was prototype number 13, which is shown again in Figure 16. This prototype is a reddish pink, 30 mm in diameter and in the shape of a circle. It is made out of wood, but this was not the main reason to choose it for any of the girls asked. The main reason this prototype was picked was its colour. Seeing that all the colours were done in pairs, prototype 7 was also a relatively popular choice. The problem with this prototype was usually the shape. The shape was seen as a little odd, not logical or like it might hurt you. The questioned girls usually preferred the round shape seen in prototype 13.

Figure 16: Prototypes 13 and 7

Another comment that was made was that the light stripes in the paint caused by the brushstrokes had an interesting effect. The effect was fairly light, which is why it is hard to see on the pictures, but according to the girls the slight relief made the coins more interesting to look at and feel. They each held a few different sizes of coins and generally concluded that the coins between around 32mm and 25mm in diameter were the best. Some girls immediately said that prototype 2, seen in Figure 17, was way too bulky and others immediately claimed that they would lose 4 and 14 in no time at all.

Figure 17: Prototype 2, 4 and 14

An interesting difference with the students from ISA was the preference from wood. Almost every girl questioned in the second evaluation had a distinct preference for wood over plastic. There were multiple reasons that they gave for this. They thought the wooden prototypes had better shapes, seeing that they were rounder than the plastic ones. They were also thicker than the plastic versions, which felt better in their hands and less like it would break. Two girls had a preference for the plastic versions because the brushstrokes mentioned before were more defined there. On the other hand, two other girls said that they did not like the wooden versions because they could splinter more easily.

From this evaluation a few conclusions can be drawn that overlap with the ones from the first evaluation as well as some conflicting ones. According to this evaluation the actual token should be made as follows:

- Colour: A reddish pink, such as seen in prototypes 7 and 13;
- Size: Between 25 and 32 mm in diameter;
- Shape: Round;
- Materia: Wood with relief brushstrokes.

The size is very close to what was gathered in the other evaluation. The material conclusion, however, is completely different. In this case the final conclusion for this will be to make the tool out of plastic instead of wood. This is, as was said in Section 6.1.3, mainly because wood is likely to go bad due to the heavy rain in the region, for instance. Plastic is a little more sturdy and also usually cheaper to make. The brushstroke effect may be gotten by engraving the Sampoorna logo in the token instead of having it put on with paint or a sticker. This would make the coin a little more interesting for girls in the age of the target group.

7. Discussion

7.1 Alternatives

Several recommendations as well as discouragements were made throughout this report. While there were good reasons to pick some options over others, alternatives are still available. An option would be to exchange connecting the girls to the machines via NFC with RFID. This would be very likely to save some money, because RFID readers are generally cheaper than NFC readers (KKmoon, n.d.; Dhgate, n.d.). The main reason that NFC was picked over RFID in this project was the problem with range that was present in RFID. The problem was that RFID tags can be noticed over a bigger distance than NFC tags, which could cause confusion in the machine. It could happen that multiple tags are present in a room that could be scanned, even when the owner of the tag does not want it to, for example. This problem would have to be solved in some way if RFID were to be used as an alternative.

An alternative that would make the production of the tools/coins easier, would be to use tools that already have NFC integrated in them instead of loose tags that have to be attached to the coin. NFC tags such as the one depicted in Figure 18 could fit this purpose. These tags can be customized in colour and logo, making them appropriate for the Sampoorna project. The ones depicted in Figure 18 have an extra piece of rope attached to them which allows girls to put them on their keys, bag, etc. but this is not a feature these girls are necessarily looking for. As was found in the evaluation, it is better to have coins that are round so that they look like regular coins and can easily be hidden when needed. Ordering NFC chips integrated in the tool directly will save the cost and labour of having to stick an NFC tag on every coin.

Figure 18: NFC tags integrated in plastic tool[11]

Another alternative for the tools would be making them hexagon or octagon-shaped instead of round. The main negative aspect to this, as was explained in Section 6.1, was that it would be easy to distinguish in a pocket. A few tests can be done to test this and if it turns out that it is not that bad, an alternative shape is a good option. This way the tools are easily distinguishable from regular rupees. On top of that, some of the evaluation participants thought an octagon shape looked very nice and different. The corners would have to be made softer, however, so no girl feels like she will hurt herself on the token.

Section 6.1 also mentioned wood-plastic composite. This would be a great material alternative for the tools, because it is better for the environment than plastic and will not go bad in the rain like wood has a tendency to do. On top of that the material looks like wood, keeping the look and feel that was praised during the evaluation. Wood-plastic composites are described by enthusiasts as follows:

[11] Source: http://www.nfcwork.com/nfc-product/nfc-keyfob-epoxy-30-mm-ntag-213-180-byte/

"*They are a sustainable solution that makes use of organic material with virgin, recycled or renewable plastics. They can be customized at low cost and without the need for investment in new production equipment. The result is a cost-competitive product that offers a lighter environmental footprint, unique aesthetic appeal and superior performance" (Green dot bioplastics, 2018, p1).*

These are the kind of qualities that may make the project even better. Although it should be noted that it is very likely that a wood-plastic composite is harder and more expensive to make than regular wood or plastic. More research and tests are needed to validate these claims.

Various types of telemetry systems were discussed in Section 2.3.2 as well as Section 4.1. In the end it was decided that Telemetron system would be most suitable for the Sampoorna project, mainly because of its extra feature of being able to tell when a door is opened or closed. This way the social workers could know when the door to the incinerator was opened, which tells them how many times it is used. In the case that this system does not work as expected for some reason, there are still other companies that offer similar services. Televend and Vendon are two examples that were detailed in Section 4.1 as well. Both of these services are able to adequately work with the Sampoorna systems towards reaching the goals. Again, tests are needed here with the actual machines present.

A different solution to the question of how to connect individual girls to the machines would be filling in numbers in the machine. Each girl could get her own number, much like a student number, for example, that they would need to memorise. The Sampoorna machines would then need a number pad that the girls could use to fill in their number in order to start up the machine. This would mean that no extra tool would need to be made and no NFC technology has to be used. This does ask more of the girls themselves, as they would need to remember their personal number. Especially since these numbers would only be used a few times per month, it may be hard to memorise. However, it is still a viable alternative that can be explored if needed and solve the loss problem that will be explained next.

A fully different kind of alternative that can be considered is using a mobile phone app to write all the personal information on the NFC tags. For this project it is said that the school will receive all the tags they need at the beginning of the school year. In order to make the tags personal, each tag will be programmed with a separate NFC writer that the school receives with the tags. Some more research about smartphone availability in rural Indian areas has to be done in order to see if writing an app for this instead is viable. If it turns out that it is, indeed, viable to have a compatible smartphone available in each school, this would be a great option to save money and time, seeing that no extra NFC writer would be needed in every school. A Sampoorna app would require at least a screen where the teacher can sign in with secret, personal credentials. This makes sure that no other people can just alter the tokens. There would also be two other functions: writing the tags and reading the tags. Reading tags can be helpful with checking if the programming was done correctly or in checking if the tag still works, for example.

7.2 Other recommendations for future work

A part of the project that has not been explored is loss protection. The question in this is what happens when a girl loses her token. While this does not have to be a terrible thing as there are no drastic things that can be done with the token, it should still be looked into. It might be a solution to "block" the lost NFC chip from working or let it be replaced by a new one. Locating the lost token may be possible by adding a GPS chip in it, for example, but this would up the costs of fabricating the token a lot, which is probably not worth it. It is probably better to just block the old one and take care of a replacement, especially if it can somehow be linked to the data of the lost token.

Another part of the machines that should still be tested in the future is the combination and communication of the Telemetron telemetry modem and the NFC reader. This would, as was recommended before, be best done with the Sampoorna machines physically there. It is vital that both of the systems are able to communicate with the other, or at least that the Telemetron system can receive information from the NFC reader. This communication is what makes the whole sending and storing of personal information possible in these machines. Testing the combination of these systems will make sure that it works, so this should be done through installing both systems in both of the Sampoorna machines and programming a few NFC tags with mock personal information. This way the whole project can be evaluated and fine-tuned.

Privacy is also a concern when dealing with sensitive data, like this graduation project is doing. In future work it should be ensured that the data is handled securely and that the girls' privacy is regarded with the utmost importance. If data about their menstruation is somehow leaked to the outside work, this could have negative implications for the girls involved. Especially now that all the taboos surrounding menstruation are still such an issue in rural Indian society.

Another different future prospect to look into would be a motivation/incentive to make sure the girls will come back to the machines to use them. A great way to get people to come back is always by offering them money. There are, however, not a lot of ways to offer girls money in exchange for using the Sampoorna machines. Giving the girls a discount on their next purchase of sanitary napkins, for instance, is an option, but is not very viable. The napkins are already cheap as it is and there is not a lot of money to spare to make this a good option.

There can be other ways to motivate the girls to come back to the machines, however. The machines could be made more fun by integrating a game, for example, or by adding another fun element to them. There could be a membership part, or even something more short like a fun fact of the month. All in all, it is just important to make sure the girls keep using the Sampoorna machine for their own health and the environment. At their age and with the social context they live in they may not understand that, however, so giving some thought to another way to motivate them to keep using the machines can really help with solving those problems too.

A last recommendation for future work is to make sure that the motivation does not lead to girls scanning their tag more than necessary. If a girl gets a discount point, for example, each time she scans her token, she may be tempted to just scan her token each time she passes the machine. This way she will get her discount more quickly, but it will make the data less reliable and does not help with teaching her about sanitary napkins and menstruation at all. In this project it was tried to make this less of an option by making the girl scan her token after making her purchase at the vending machine. Whether or not this is enough and if it works at all for the incinerator should be tested in future research.

8. Summary and conclusions

In Section 1.3 the general research question as well as the further sub questions were discussed. The research question throughout this project was: What is the best way to connect both parts of the Sampoorna project to each other and keep track of interesting (personal) data to send to the social workers. The sub questions are as follows:

- How can the machines be connected to each other and the social workers?
- How can the machines keep track of personal, interesting data?
- How can this data be sent to the social workers?
- How can personal, identifiable information be connected to the data?

Throughout this chapter of the report these questions will be dealt with. They will be analysed and answered to the extent possible. On top of that this chapter will also show a usage scenario to make it clear how the final project would work in a "real setting".

8.1 Sub questions

8.1.1 How can the machines be connected to each other and the social workers?

This project has found that the best way to connect the machines would be through telemetry. There are two options within this: either making a new, specialised telemetry system or using an existing one. In this case using an existing system was chosen. The reason for this is mainly based on time and financial constraints. Developing a personal system would require a lot of time, money and technical knowledge that the Sampoorna project does not have available as of yet. Using an existing system does not require any of those and would work perfectly fine with the needs of the Sampoorna machines. Later on after the project has become more well-known and is installed in more places, developing a new, specialised system can still be considered.

The system that was chosen for this project was made by a company called Telemetron. It consists of telemetry modems and a desktop program to make use of the collected data. The modems would be installed on both types of machines (the incinerators as well as the vending machines) after which they could send the information gathered to the program. This information could be things like inventory or maintenance issues, or usage patterns, such as when a machine was used that day. All of this could be seen by the social workers involved after they log in to the desktop program on their personal account. This way, they could access all the important data, analyse it and use it to improve the way the machines are used and how well menstruation is understood.

8.1.2 How can the machines keep track of personal, interesting data?

Throughout this project it was found that personal, interesting data should be kept track of by using individual coin-like tokens with added NFC technology. Each girl would have her own token as described in Section 5.3. The final prototype can also be seen below in Figure 19. There are several reasons that NFC is used instead of other options, such as RFID, Bluetooth or EMV technology. NFC has an ideal range, for example. An NFC chip has to be held directly on top of the reader or just a few centimetres apart from it, which means that it can only be scanned when a user really wants it to be scanned. NFC chips can easily be programmed to contain the data that is needed to know what girl the coin belongs to, such as her name and birth date, for instance. This kind of information is so small it does not take up nearly all the space provided on a chip and makes sure it is still quickly scannable. Both types of machines will have an NFC reader installed on a reachable place, which the girls can use to scan their personal token. The machine will then know who did the accompanying actions, such as buying a new sanitary pad or burning an old one.

Figure 19: Final prototype, what the token should look like

As can be seen in Figure 19, the token has to look a specific way. The reasons why it looks like this can be found explained in Chapter 6, Evaluation, and Section 5.3. The final token as it was made in this project is a deep red-pink colour, shaped like a circle and 29mm in diameter. While the final prototype was made out of wood, the real token should be made out of plastic. The wood was mainly chosen here due to the time constraint. The reason plastic should be used instead of wood is because wood will more easily go bad. It is easy for wood to splinter or go soggy after heavy rain, for example, while this is not a problem with plastic.

8.1.3 How can this data be sent to the social workers? And how can personal, identifiable information be connected to the data?

These questions were taken together because their answers tied in together very well. The data that is collected by using the individual tokens will be send to the social workers through the telemetry connection. The telemetry system knows the conditions of the machines, such as inventory, and can combine what happens to the information gotten from the token. This way the social workers' program will show, for example, that a sanitary napkin was bought from the vending machine at 12:10 by user A. This will all be sent through a GSM connection that the Telemetron system uses. In the case it is impossible to combine the NFC technology with the Telemetron system described in 8.1.1, amongst other sections, a new system would have to be realised or an alternative to NFC will have to be used. In order to make sure of this more research has to be done, as was argued in Section 7.2. It would be of great help if one or two of the Sampoorna machines would be available and present for this.

8.2 General research question

The main research question this report aimed to answer is:

What is the best way to connect both parts of the Sampoorna project to each other and keep track of interesting (personal) data to send to the social workers.

In order to answer this question a lot of research was done, prototypes were made, evaluations were held, etc. Because of these endeavours, an elaborate answer to this question can be given. A big chunk of the answer has already been given in answering the previous sub questions, so combining these will solve the research question of this project.

According to the extensive research done during this project it can be said that the best way to connect both parts of the Sampoorna project to each other and the social workers is telemetry. Existing telemetry systems can keep track of inventory, maintenance issues and more, which is exactly what was asked for in this improvement of the machines. Through telemetry the social workers will know exactly what is going on with the machines and its users. In order to connect the users of the machines even more to the social workers, personal data was kept track of. The research done showed that this data should be gathered through personal tokens with

NFC technology. These tokens would contain the user's name and date of birth, making it easy to distinguish which token belongs to who. Using this token at the machine allows the social workers to know who used which machine at what exact moment. This gives them a useful insight in usage patterns of the users concerned.

8.3 Usage scenario

The following usage scenario describes how the solutions described in Sections 8.1 and 8.2 would be used "in real life".

At the beginning of the school year the girls at the school each get their own token from their (female) teacher or social worker. This token will be programmed by their teacher, who will get an easily understandable guide on how to do this with a mobile phone or separate NFC writer. The guide has a template that will tell them to program a name and date of birth, so they know how to distinguish different girls. With this information programmed the token is ready for use. A good place to store the token would be a wallet or even a school bag or pencil case.

When a girl gets her period she will need a sanitary napkin. In order to get this, she will go to the Sampoorna vending machine that is installed in her school. In most cases, this machine is located in or near the women's toilets. First, the vending machine asks the girl to insert the needed coins and push the button. A sanitary napkin will be dropped in the bin at the bottom of the machine, but before getting it the girl will be reminded by the machine to scan her personal token. This is mainly because the NFC reader is placed in a logical, noticeable place on the machine, as was shown in Chapter 5. The girl scans her personal token here, so the machine knows who is using it. The machine sends her name and birthdate to the social workers as well as information about her purchase, inventory, etc. Lastly, she grabs her sanitary napkin from the container. She can then proceed to use her sanitary napkin as she was told and her interaction with this machine is, for now, finished.

Depending on how heavy her period is and what her school schedule is like, she will need a new sanitary napkin a few hours later. The actions described above here will be done again, after which she will need to dispose of her used sanitary napkin. For this, she needs to go to the Sampoorna incinerator, which is in most cases installed close to the vending machine. First the girl will scan her personal token again on the NFC reader on this machine. The information will, again, be sent to the social worker so they know this girl is using the incinerator. The girl then opens the incinerator's door, deposits her old sanitary pad and closes the door again. This is everything she needs to do with this machine. The telemetry system installed on the machine will make sure the needed data is sent to the social worker through a GSM connection of most likely 900 MHz or 1800 MHz. The information gathered by both this machine as well as the vending machine can then be seen and analysed by the social workers in their personal desktop application.

Also, note that the use of the NFC tag is not completely necessary here; the Sampoorna machines will still work if the tag is not scanned. This is done with reason. The machines are not only installed in schools, but also in some other public spaces. Not all women who access these machines will have their own tags as not all of them attend school anymore. This way these women can also get sanitary napkins when they would not have been able to if the tokens were absolutely necessary to access the machine. On top of that, girls still have the option to get sanitary napkins when they forgot their token at home or lost it, for example. Using the token will be encouraged, but the choice to not use it will also still be there.

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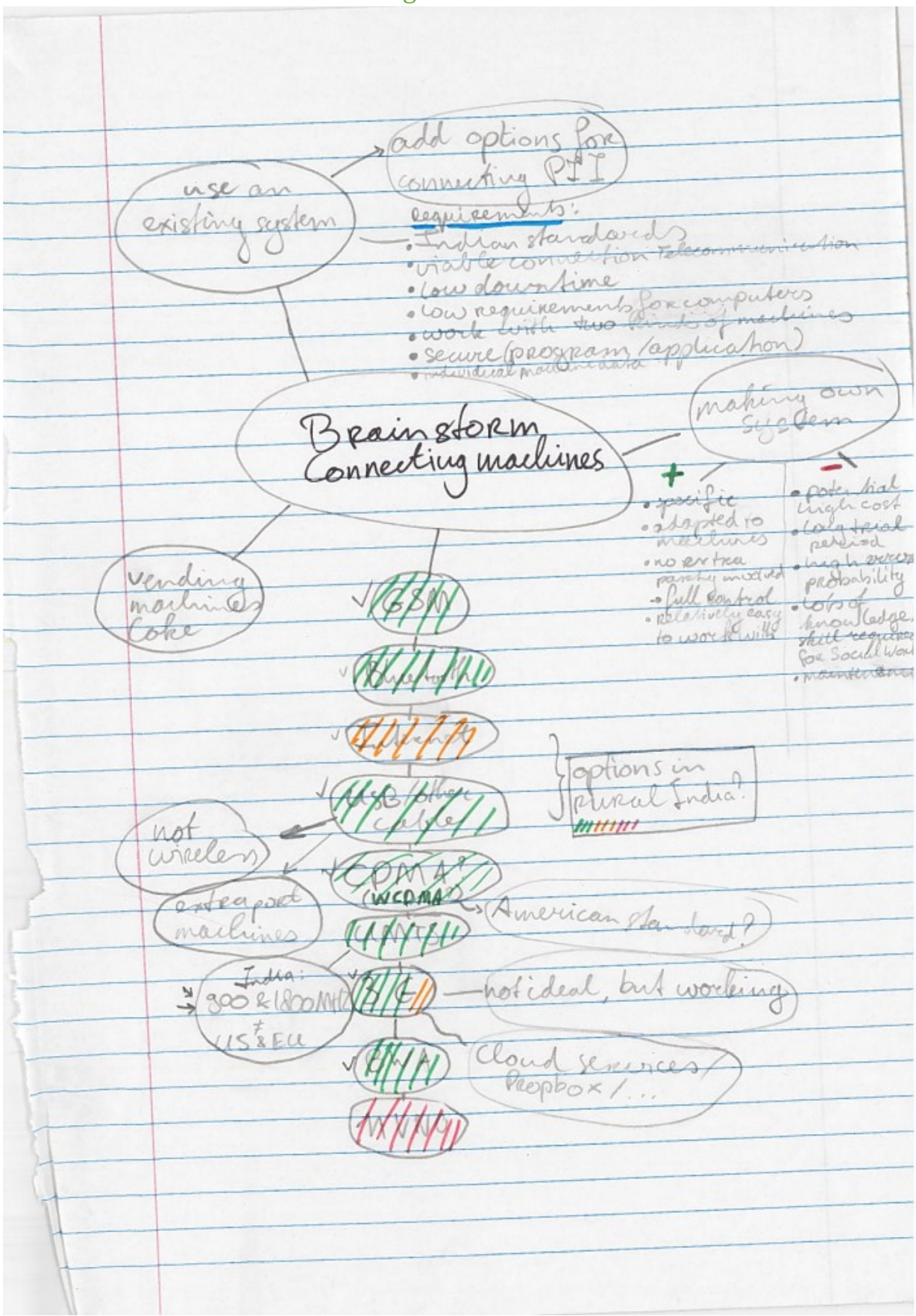
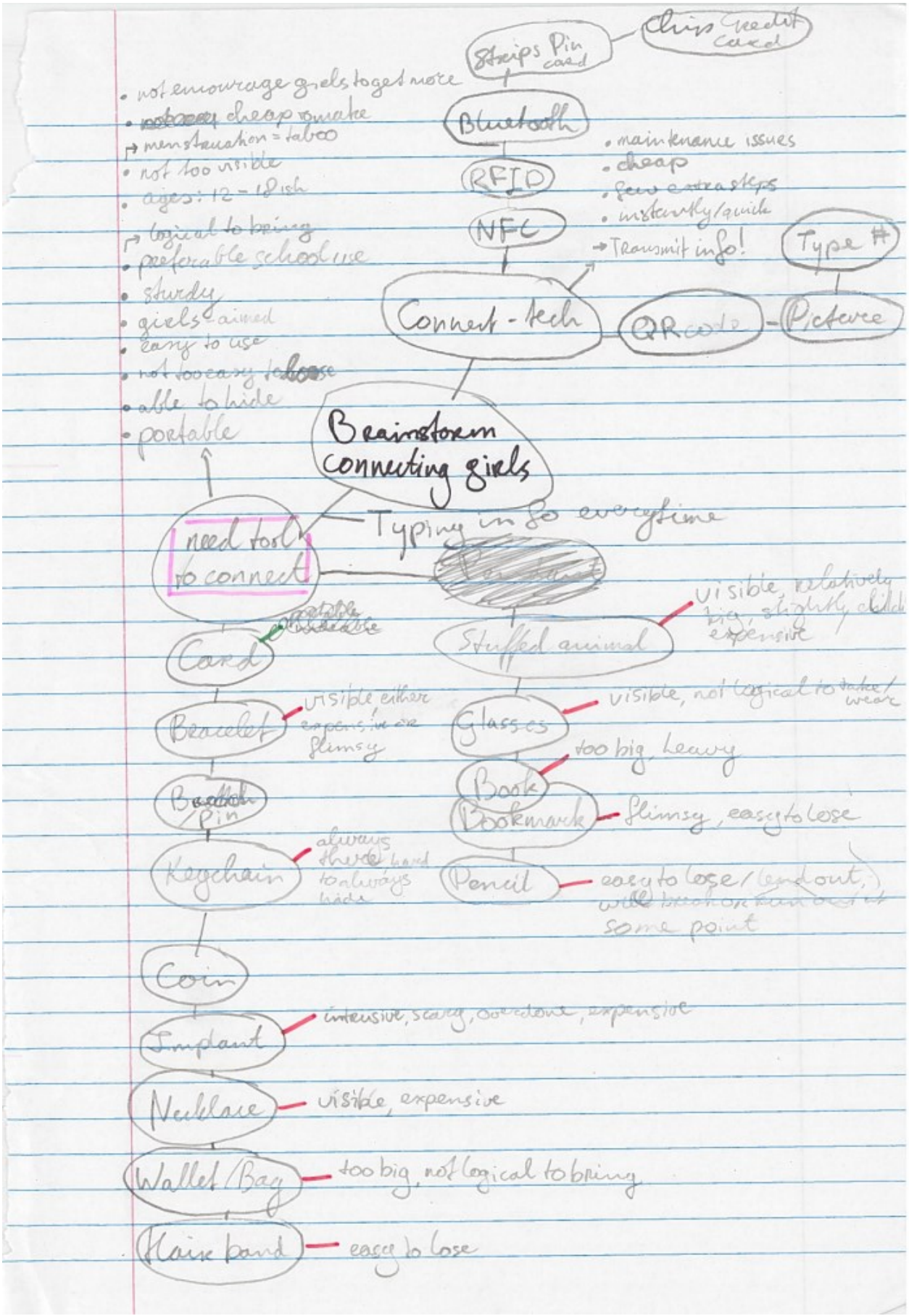
10. Appendix

10.1 Brainstorm connecting machines



10.2 Brainstorm connecting girls



10.3 Sampoorna vending machine

12

[12] Source: Personal file Dr. Rana

10.4 Sampoorna incinerator

13

[13] Source: Personal file Dr. Rana

10.5 Evaluation form coin prototypes

#	Colour	Shape	Material	Size	Other
1	1	1	1	1	1
2	2	2	2	2	2
3	3	3	3	3	3
4	4	4	4	4	4
5	5	5	5	5	5
6	6	6	6	6	6
7	7	7	7	7	7
8	8	8	8	8	8
9	9	9	9	9	9
10	10	10	10	10	10
11	11	11	11	11	11
12	12	12	12	12	12
13	13	13	13	13	13
14	14	14	14	14	14
15	15	15	15	15	15

10.6 (Dutch) Consent form parent/child

Enschede - Mei 2018

Beste (ouders van) redders,

Voor het afronden van mijn bachelor Creative Technology aan de Universiteit Twente ben ik bezig om een scriptie en afstudeerproject te maken. Voor een onderdeel van dit project onderzoek ik muntjes van verschillende kleuren, maten en materialen. De doelgroep voor het volkomen vrijwillige deelonderzoek is meisjes tussen ongeveer 11 en 15 jaar oud en de vraag is welk van de “muntjes” volgens hen het beste is. De enige vragen die worden gesteld zullen ook hier over gaan en antwoorden zullen volledig anoniem genoteerd worden. Er zal ook geen beeldmateriaal gemaakt worden.

Het onderzoek zal vijf à tien minuten duren aankomende vrijdag. Als u als ouder of uw dochter zelf niet wil dat zij meedoet aan het onderzoek zal dat uiteraard dus niet gebeuren. Ook tijdens het onderzoek kan ze zich altijd nog terugtrekken. De reden dat dit formulier ondertekent moet worden in plaats van een mondelinge toezegging is het feit dat dit wel een onderzoek is voor een afstudeerproject en problemen met de ethische commissie van de Universiteit Twente voorkomen moeten worden. Mocht u nou nog andere vragen hebben dan kunt u mij altijd aanspreken aan het bad of een mail sturen op het volgende mailadres:

a.e.a.groen@student.utwente.nl

Alvast bedankt voor uw medewerking!

Allyne Groen
Creative Technology - Universiteit Twente

Naam van kind: …….

Naam ouder: ……..

Mijn dochter mag wel / niet meedoen aan het bovengenoemde onderzoek (doorhalen wat niet van toepassing is).

Handtekening ouder: ……

10.7 Ethics review

Introducing the Sampoorna Project

The project that is central in this graduation project is called “Sampoorna”. The Sampoorna project consists of two machines: a vending machine and an incinerator, both depicted below. These machines are developed and built by EcoDev Solutions, a company based in Calcutta, India. The machines are set up in regular schools in rural India, for now mostly in the area around Calcutta.

Figure 10.7.1: The Sampoorna vending machine and incinerator[14]

The vending machine sells separately-packaged sanitary napkins to local girls for a relatively affordable price. Through this, the machine is meant to solve the two main problems that stop girls from using sanitary napkins: the high costs and low availability of sanitary napkins (Rana, personal Communication, March 13, 2018). This way the girls have an easy way to get sanitary pads as an alternative to e.g. the old cloth that they tend to use now. This is necessary, because it helps prevent period-related diseases that stop the girls from going to school. A study by AC Nielsen and Plan India (2011) (as cited in Van Eijk et al., 2016) shows girls on average miss 50 days of school and that 23% of rural girls even drop out of school. More information on this will follow later on in this report.

The second part of Sampoorna is an incinerator that is meant to be located closely to the vending machine. This is a machine that lets the girls get rid of their old, dirty, used sanitary napkins (EcoDev Solutions, n.d.). This machine is also necessary, because currently girls usually dispose of their sanitary pads in ways that are bad for their own health and/or for the environment. Both machines are mounted on a wall and include instructions written on them in English or the local language if that is spoken more commonly.

The part of the machines that this graduation project is mainly about, is installing a connection between the machines and social workers that will provide the social workers with useful data about usage patterns, for example. Ideally, this would include personally identifiable information too, so that social workers will have the opportunity to help individual girls. If a girl struggles with understanding a part of the machine or their menstruation cycle, a social worker can step in to help her. While this help is a positive addition to the machines, there are also some

[14] Source: Personal communication with Dr. Subrata Rana of EcoDev Solutions

issues that come with it. These issues will be discussed in the following sections of this report. First some cultural differences, history and taboos will be discussed and what these were like in Western society. After that privacy concerns will be analysed, as well as the price of the sanitary napkins, and persuasive technology. The last section will draw some conclusions from the topics that were explored.

Cultural differences

Differences related to design

An important part of the background research that had to be done concerned cultural differences between India and the Netherlands (and Western cultures in general). It would be rash to assume that everything that works here would also work in India. A random example could be the way cows are viewed. In the Netherlands cows are just seen as animals that produce milk, while in India they are worshipped and seen as the "most evolved of animals" (Kesavan, as cited in Biswas, 2015). Using a cow for an icon would be fine in the Netherlands, but in India it would be met with severe criticism. Some of the cultural differences will become clear throughout this report, such as differences in the way privacy is perceived.

An important ethical issue that is seen differently in the Netherlands and India is the way menstruation is treated. While menstruation is not a taboo in most Western countries, it is still a topic that is not spoken about in India. Because of this it is hard for girls to know anything about the topic before it starts and a lot of misconceptions arise. Even though in Western cultures it is perceived as wrong to disapprove of (talking about) menstruation so strongly, it still has to be taken into account when designing for the Sampoorna machines. For instance, when a tool is used to connect the girls to the machine, it should not be too visible or easy to hide. Making such a tool very obvious would only get the girls in unnecessary trouble, as everyone would know that she is on her period. This could lead to her not being allowed to prepare food or touch religious figures, amongst other restrictions (Srivastava, 2018). Even though this situation is changing, not bringing attention to a girl's period will protect them from unnecessary restrictions and other unpleasant situations. Even when it is against the Western viewpoint that it is wrong to impose these restrictions in the first place.

History and taboos

These taboos that were mentioned in the previous paragraphs did not just appear out of nowhere. For centuries menstruation has been a taboo in India as well as other countries and cultures. The myths and taboos date all the way back to when the Vedas (ancient religious Hindu texts) were written (Garg & Anand, 2015). This happened somewhere between 1500-1000 BC, so more than 3000 years ago (Violatti, 2018). According to Garg & Anand (2015), the myths are linked to when Indra ("King of the Gods") killed a demon called Vritra. After this killing Indra felt guilty and had sin surrounding him. One of the Hindu books tells the outcome of the story as follows:

> *"However, he escaped his punishment by distributing the sin among the land, water, and women. (…) In return for ridding Indra of the sin, earth got water to fill its empty holes, trees got re-growth of cut branches, waters became purifying, and women obtained undiminished sexual desire. As a result of their share of the sin, earth has wastelands, trees have sap, waters have froth, and women have menstruation."* (Canto 6, Chapter 7-13, as cited by ApamNapat, 2004, p1)

Because of these beliefs it is still thought that menstruating women are unclean and surrounded by sin and guilt. This is the reason that they can be told to stay indoors, not use the kitchen or a prayer room, sleep on the ground, stay away from school, etc. (Changoiwala, 2017). There are initiatives such as the Sampoorna project that try to show that menstruation is very

normal and does not have to be shameful or unspeakable. However, because of the fact that these beliefs have been prominent in India for so long it will take some time to do so.

Problems and solutions in western societies

Even in Western society there are still some taboos concerning (talking about) menstruation, which shows that it is hard to fully overcome these things. Similar practices as the ones happening in India right now (excluding women from certain activities, prohibiting them from touching certain foods, etc.) were prominent in Western culture too. Ancient Greeks thought that a late period meant that blood was clogging around the girl's heart while her uterus was wandering around her body. Because of this up until about fifty years ago any "inappropriate behaviour or poor mental health in women" (p1) was called after the Greek word for uterus: hysteria (Hampton, 2017). In 1919 a paediatrician 'proved' that menstruating women caused flowers to die sooner. Another medical study in 1916 claimed that menstruating women prevented milk from turning to butter, amongst other things (Hampton, 2017). These claims may seem ridiculous, but were still made relatively recently.

Even nowadays there are still things that show that it is not fully okay to speak about or show menstruation. For instance, in basically every advertisement for sanitary napkins ever made, the absorbing qualities of the pad are shown with a blue liquid, never a red one (Thorpe, 2017). However, over the past centuries Western cultures have made a lot of progress. Women have relatively few restrictions or limitations based on whether or not they are on their period. This is mainly because of good research and educating everyone, including men, about menstruation. An example of this is the Disney-made educational animation film called 'The Story of Menstruation' which was shown to over 100 million high school students in the USA around 1946. This film encouraged girls to live their lives like they would do any other day, and made menstruation seem more normal than before for both girls and boys (Hampton, 2017). While there was still a long way to go from there, initiatives like this one helped. The fact that women were allowed to vote, for example, at some point in the 20th century in most Western societies helped too. Women were allowed to speak more, raise questions and stand up for themselves and what was important to them in general (Menstruation-Matters, 2018). Therefore, educating everyone in society about menstruation and allowing women to speak more freely about matters concerning them could very likely be beneficial to Indian society too.

Privacy

Personal data and access to it

As was mentioned in the section 'Differences related to design', privacy is viewed differently in India than it is in the Netherlands or the United States, for example. In India people are generally less aware of and less concerned about issues concerning privacy (Kumaraguru & Cranor, 2006). Only 2% of Americans are always comfortable with sharing their phone number online, a study by Kumaraguru and Cranor (2006) claims. On the other hand, 14% of Indians are totally fine with sharing their phone number online. This difference in seeing issues is confirmed by another fact in the study, which shows that 6% of Americans are always okay with sharing their medical and health history online, compared to 29% of Indian internet users. Since internet safety is not taken as seriously in India as in other countries, extra emphasis has to be put on privacy and security in order to protect all the data that is collected and used in the Sampoorna project.

Collecting personal data always brings some complications, with privacy being the most obvious one. Each girl will have to submit some personal data in order for the social worker to know which transaction was done by who. This personally identifiable information is very likely to contain things like a name and/or date of birth and can therefore easily be used to identify a

person. Every person that has (access to) this data can then easily identify things about these girls that they want to keep private (Sweeney, 2000). Think of the timeframe in which their menstruation happened and will likely happen again or if they are on their period at that moment. It could even show periods of time in which their menstruation did not occur when it should have, indicating signs of illness or pregnancy. It is vital to protect the privacy of these girls by limiting the amount of data that is gathered to the minimum required and by keeping the place that the data is stored secure.

Why this exact data is private is debatable. As James Rachels (1975) said in his paper on privacy, what we think of as private "should help us to understand what makes something "someone's business" and why intrusions into things that are "none of your business" are, as such, offensive" (p326). In the case of the Sampoorna project, it will be assumed that information is private because of the effects it may have if it were to be put out in the open. Sharing, for example, the information collected by the vending machines online could result in the girls involved getting in trouble, as was explained before. Therefore, it is justified to put extra care in keeping the data safe and secure.

Keeping the data safe is also a matter of access. Seeing that the data is personal, intimate even, it is difficult to tell who should have access to the data. Social workers that are using the data to help the girls should be allowed to access the data, seeing that they are the reason that the data is collected in the first place and they will solely use it to help the girls involved. However, when social workers share the data with others, that might turn out to be problematic. Even though sharing information with the parents of the girl sounds innocent enough and beneficial to the girl, it might not be. If the girl is hiding something from (one of) her parents without the social worker knowing, sharing the personal information might get them in a negative situation. Maybe she is hiding from an abusive family member that can find out her address through this machine, or maybe the parents don't approve of her using sanitary napkins instead of traditional solutions, or she might not even have told her parents about starting her period at all. All of these reasons show that having access to the data should be limited to the social workers that need the data. Of course there might be exceptions where this data comes in as proof for an illness, for instance, but these are highly exceptional and should be avoided if possible. In any case of sharing the information, asking the girl in question for her consent will make it less invasive of her privacy.

Chilling effects

The privacy issues that have been described before may also result in another problem: chilling effects. A chilling effect is when people behave differently because they know that they are being watched or that there may be sanctions for what they are doing, for example. In the case of the Sampoorna project the chilling effects for the girls can potentially come from knowing that what they are doing is recorded. The girls that use the machine will know that when they get a sanitary napkin or dispose of one, the social worker can know exactly when and where that happened through the new technology.

Especially with the taboos still surrounding menstruation in rural India, the chilling effects may lead to girls refraining from using the machine. They may feel watched, but they may also feel that the fact that they are on their period is not secret anymore. In wanting to keep her menstruation a secret and keep her privacy, a girl might avoid using the machine, even though it would be better for her health to use it. If the girl then still chooses to use the machine, she may use it differently because she feels like she is being watched. She might get less sanitary napkins, thinking that it would be weird to get more than one every two days, for example. Or she might get more, figuring out that she is somehow supposed to, even though she does not understand why. This would still leave her with unanswered questions, while it looks like the girl is doing

fine to the social worker. These misunderstandings should be avoided by explaining clearly on the machine what a girl should do and why. This way a girl will be more easily sure that what she is doing and feeling, for instance, is normal and correct.

Price of the sanitary napkins

There are also different parts of the machine that raise some ethical questions, other than privacy issues. The sanitary napkins themselves are one example. The main reasons girls use the sanitary napkins from the Sampoorna vending machine is that the napkins are affordable and easily available compared to getting them in a nearby city, for example. Because the sanitary pads are relatively cheap, it is a good alternative to the cloth and other unhygienic things they use now (AC Nielsen Group & Plan India, 2010). The question that remains, however, is *why* these sanitary napkins are this cheap.

There can be multiple explanations that the sanitary napkins can be sold for a low price, some of them more ethically appropriate than others, as is usually the case when looking at material choices. Cheap clothes, for example, are made by underpaid, sometimes very young, workers in Bangladesh under bad conditions (Parry, 2017). While this approach would help the girls in rural India, the situation for workers in Bangladesh would definitely not improve. There is, however, also a positive option. Some companies manufacture their own sanitary napkins locally in small "factories" with local workers, mostly women, that get a fair wage for their work (Joshi, 2015). This way the situation for both young girls and adults would improve in rural India. Fortunately, the Sampoorna project is more like the latter option than the first.

An article in the Millennium Post (2016) tells about one of the places where sanitary napkins for the Sampoorna project are made. "Women rescued from trafficking have been provided training to work at the unit on salary basis thereby finding an alternative source of income" (p1). Local women that are in need of a job are employed for the Sampoorna project. This improves the conditions for the workers as well, seeing that they would otherwise have had to work for a farmer on the land for less money, for example. Although it can be said that by doing this other people are deprived of the job of making sanitary napkins, this is not really true. There were barely any sanitary pads available in rural India, so no one had to make them. Therefore, no-one's old job was taken away in the process.

Persuasive technology

Another angle that can be used to look at this project is the persuasive technology angle. As was explained before, in this graduation project the machines are connected to each other and the social workers, while the girls are "connected" to the machines via personal information. This way the social workers know whether both types of machines are used correctly or not. Important information/data could be if the girl that just bought a new sanitary pad also gets rid of her old one within the same timeframe. Some girls may do this automatically without further hints, but others may need to be persuaded in some way.

There are different aspects to persuasive technology, as Sunstein and Thaler (2008) describe in their book. An important aspect is incentives, especially related to the topic of the Sampoorna machines. There has to be something that motivates a user to do a certain action that the developer deems right, an incentive. Usually this incentive is somewhat price-related, as it can be a discount or a price increase. It should also put in a perspective that the user can understand. Sunstein and Thaler give a good example of this. They explain that it may be good to show a person in a gym how many calories they have burned, but: "Even better, for some, might be a pictorial display that indicated the calories one had burned in terms of food: after ten minutes one had earned only a bag of carrots but after forty minutes a large cookie" (p99). This shows that some concepts are more easily grasped by the target group than others. In the case of

the Sampoorna machine, this could, for example, translate to the incinerator. You can tell the young girl that using the incinerator has saved a certain amount of plastic in the environment or you could show them in terms of, for instance, flowers or fish saved.

Therefore, in order to encourage a girl to destroy an old sanitary pad after buying a new one persuasive technology can be used. They may get some reward for completing one action after the other, for instance, or a screen could give the girl a reminder that she should get rid of her old sanitary pad. This is an alternative to the usual way of disposal, which is a lot more often than necessary just throwing the pad somewhere in the bushes, for example. This way a girl is encouraged to do the actions that are better for herself as well as the environment. While put this way this sounds ethically appropriate, but there is also another side to it. Encouraging the girl to do one action should not limit her options. It may be good to get rid of a sanitary napkin at school, but the girl could also have thrown away her old pad at some other place. She might not even have an old pad, seeing that she could have just started her period that day. Encouraging the girl to keep the old pad for a long time is an unwanted, erroneous effect of the persuasive aspect of the machines and the project.

Girls should have the option of ignoring the advice the technology gives them, seeing that it should just be advice. While it may be a good idea to buy a new pad every so many hours, a girl could have a personal reason to not do so. The option to not buy a pad after a few hours should not somehow be taken away from her. This obviously counts for all the options the girl has, such as throwing away old napkins, buying multiple napkins at once, etc. This way the girl still has a choice. All the while, it is important that the girl knows that, for instance, throwing away her old sanitary pads in the incinerator is the best option for the environment and her health. There has to be a balance between how much a girl is encouraged to do a certain action instead of another, while not limiting her to this option only, to make sure she can still do something else if she believes that to be better.

Seeing that the social workers have access to a lot of relevant data because of these systems, they play a part in this too. Girls should still have the option to do the action that the machines do not recommend, but the social workers will know that they did this and ignored the advice. If the social worker notices that this happens systematically, they might feel like they need to do something about it. They could then take the girl apart and ask her about her habits and why she chooses to buy less sanitary napkins than recommended, for example. The social worker can then easily explain things to the girl and help her if needed. This is also a form of persuasive technology, seeing that the social worker used the technology to figure out what exactly the girl needed to be encouraged to do.

Conclusion

All of these different points point out that there are a lot of ethical issues surrounding the Sampoorna machines. Some of these questions arise because of differences between Western and Indian culture, others because of technology that is (or will be) implemented in the project. Issues like privacy, for example are very pressing at the moment, mainly because of the ideas and opinions on privacy are now changing rapidly worldwide.

Privacy is viewed differently in India than it is in The Netherlands. Studies have shown that people are less careful with their data online in India. Because of facts like this it is even more important to guard the privacy of the girls that are using the Sampoorna machines. The data that is used is relatively easily traced back to the person that supplied it and very sensitive as well. Through the data collected, a person would know when a girl is on her period, when she is likely to get it again, etc. Therefore, to protect the girls, there should be a lot of thought put into who is allowed to get access to this data. While the social workers that the data is collected

for should get the data to help the girls with their individual problems, parents, teachers or other people that are somehow involved should not be given access without the girl's consent. The information given could be used in a negative way against the girl, seeing that there are still a lot of taboos surrounding menstruation in (rural) India.

These taboos stem from common religious beliefs and have been around for centuries. They result in women being restricted in a lot of ways, such as where they can or cannot go. On top of that the taboos result in girls and women being unable to talk about their "shameful" menstruation, which in turn leads to ignorance and health problems. While it would definitely be good to get rid of these taboos, it will take a lot of time to do so. In the meantime they have to be considered when working with this sensitive topic, even when it is against the more Western viewpoint of it being wrong to restrict girls for this reason. Attracting unnecessary attention towards a girl for being on her period could result in her being mistreated or restricted in various ways. This should obviously be avoided for the wellbeing of all the girls and women involved.

Another way the wellbeing of women is taken into account in the Sampoorna project is the way the sanitary napkins are made. A new opportunity of work is created for local women through the project: by fabricating the sanitary napkins the women earn some money, a fair wage for the work done. The sanitary napkins they make are relatively cheap and easily available too, as they are mostly sold in local schools. These factors make it a great, viable, and above all way more healthy alternative to the old cloth that girls there tend to use now. So, not only the situation of girls still going to school improves, but also the older women living there benefit from the project.

It was also discussed that girls in schools are "persuaded" to use the Sampoorna machines (again) through subtle persuasive technology used. While using sanitary napkins and getting rid of them in the incinerator is good for their health as well as the environment, there should still be an option to refrain from using the machines. There can be various reasons a girl does not want to use this vending machine or incinerator and they should not feel obligated to do so. The data that the social worker receives or does not receive should tell them something about a girl's habits. If this worries them for some reason, they can always ask the girl about it instead of persuading her to do a certain action that seems best.

All in all, it can be said that there are various ethical angles to this project that all contribute to understanding the implications and problems it entails. There are good reasons that the Sampoorna machines are being implemented in schools and good reasons that they are being improved. That does mean, however, that a lot of different factors have to be taken into account. Fortunately, a lot of factors are positive. The machines help with breaking the taboos, help the girls in getting an education and improve their future prospects. Dealing with the various ethical dilemmas in a proper way will improve the project even more and help achieve those goals. The fact that something as simple as sanitary napkins can help so many people, shows that there is more than enough reason to continue the Sampoorna project and help these girls get to a better, healthier future.

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