

# Sleeping Buddy

Smart environments project documentation report

CreAte Y1 module 2

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# UNIVERSITEIT TWENTE.

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## Chapter 0: Introduction

Disasters are horrible. When you think of disasters, you probably think about earthquakes, floods or other natural disasters. But there are in fact disasters going on right now, that are unnoticeable. It is hardly talked about but has a huge impact on our daily lives and the economy. We're talking about sleep deprivation.

It might at first not sound like a disaster, but with over 73 % of students not getting enough sleep <sup>1</sup>, this has drastic consequences for our society. We are willing to bet that you have encountered some sort of sleep deprivation in your life. Whether you have suffered effects like irritability or fatigue, or have encountered others that suffer from it, sleep deprivation causes problems. In extreme cases, some people develop chronic sleep problems, depression and paranoia. Sleep deprivation is nothing to be joked about and not yet properly solved. However, in this project, we have tried to tackle this issue by developing and creating a sleeping buddy, which is meant to monitor your sleeping habits and improve sleeping cycles using scientifically proven methods for better sleep. As sleep deprivation can cause a numerous amount of health related issues, this invention can prove to be both innovative and useful!

## Chapter 1: Literature Review

In this chapter, we brainstormed some possible ideas for disasters that we could tackle. We came up with quite a lot of ideas, did some research on them and summarized them below. Some summaries discuss existing solutions for disasters, others address a current problem that still needs a solution.

### **Small town monopoly.<sup>2</sup>**

Summary: In William Conkwright's town there is a small, inadequate, and unpleasant supermarket. It being the only one, he travels to a town further up with another, much more pleasant and adequate, supermarket which he is a regular customer of. He discusses the changes he notices and his thoughts in the matter when the big time supermarket 'Walmart' sets up shop across the street from the shop. The competition it brings pushes the competitors to lower prices, higher quality products, and better customer service.

### **Cow abuse in the world<sup>3</sup>**

Summary: The link shows a video of cow abuse filmed on a cow dairy farm by someone who went undercover for 2 years to reveal its moral misconduct to the world. The writer's detailed experiences and sightings at the farm, as well as some information on dairy companies related to this, are written in the form of a blog.

### **Internet down- survival pack<sup>4</sup>**

Eliminating all internet communications, even if only for a few days, would inflict huge economic costs," says Thomas Hazlett, who served as chief economist of the Federal Communications Commission in the early 1990s. "Look at the economic damage wrought by the 9/11 attacks that closed Wall Street trading and cut off international flights in a large part of the world for about a week. Those losses are calculated to be over \$120 billion." Basically the world's economy would collapse in a matter of days.

### **Civil war**

Summary: Civil wars are hard to control. Historically, many civil wars or revolutions started with an uprising of the civilians against the government or the king. A century ago, these conflicts were usually ended with the civilians regaining power by overthrowing the government. Nowadays, protests around the globe are carefully monitored by the government. Governments in east Asia tend to shift the law in their favor to regain control. By shutting down every temptation of protest by law, a civil war can be avoided. However, using fear to suppress civilians to retain power would not be considered morally correct in the west. There is no 'survival kit to prevent a civil war'. Civil wars thankfully are not common in democracies, because problems and protests are often resolved by the government. Therefore, the best preventive way to prevent a civil war is to have a well working political system.

### **Health checks at festivals and other busy places**

First-aid is a basic requirement at festivals. If it wasn't, festivals would be a disaster. Due to drug abuse, people bumping into each other or alcohol poisoning, it's important there are enough ways to help patients as quick as possible. Planning the location of these first-aid tents can be problematic, as they need to be as close as possible to choke points and require quite some space. We are wondering if there are any alternatives, but so far have not been very successful. .

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## **Sleep deprivation:** <sup>5</sup>

In this article they talk about research they did about sleep deprivation/restriction. The test showed that a sleep restriction of 6 to 4 hours led to the same effect as total sleep deprivation for two days. Also the sleep restriction had cognitive effects the participants weren't even aware of.

## **Coral death:** <sup>6</sup>

In this article the author talks about research he did in Hawai'i. He researches the correlation between loose fishing lines and cauliflower coral. In his research he showed a direct cause and effect between them.

## **Campus isolation:** <sup>7</sup>

In this article they talk about the mental health of student before and after the pandemic (and social isolation). It shows student without previous mental issues are now suffering more from them because of the isolation.

## **Gaming addiction:** <sup>8</sup>

In this article they talk about how gaming affects people's social skills, families and focus. The addicts often are young and tend to have psychological or social problems.

## **Climate change** <sup>9</sup>

Climate change is a serious global problem that will not go away until it is properly addressed. Because we are already committed to some level of climate change, we have two ways to deal with this issue: adaptation and mitigation.

Adaptation means that we will have to adapt ourselves to the situation and live with the effects of climate change. Examples of this are building flood mitigation systems, develop resilient crops and invest in water infrastructure. Mitigation means to actively solve the problem, by for example lowering the amount of greenhouse gasses in the atmosphere to lower the global temperature. This can be done by reducing the amount of these gasses released into the atmosphere and/or by storing these gasses in sinks like forests, oceans or soil.

## **Pollution (plastic)** <sup>10</sup>

There are three main problems with our plastic use today:

High-income countries tend to produce a high amount of plastic per person. Although this is not good, due to good infrastructure and waste management systems not much waste finds its way into the sea.

Low-income countries on the other hand tend to mismanage (plastic) waste, causing a lot of pollution. Often due to rapid industrialization and a lack of waste management infrastructure a lot of their plastic ends up in the oceans.

Another large part of plastic pollution traces back to marine sources, the biggest of which is abandoned fishing gear.

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An idea for our project could be to develop a product that helps one of these three categories.

## **Global obesity<sup>11</sup>**

worldwide obesity has tripled since 1975, with 19% of all adults over 18 being obese in 2016. The WHO blames global obesity on two trends: the increase of consumption of energy dense foods, that is foods with a high content of sugar and/or fat and the decrease of physical activity in people's daily lives. This has to do with the fact that more and more daily activities, work or other, are done seated. Both these trends come from environmental and societal changes.

The health risks associated with obesity are cardiovascular diseases, diabetes, musculoskeletal disorders and some variations of cancer. To decrease the chance of obesity the WHO suggests a healthy diet and regular exercise. On a societal scale, the food industry could have a big positive influence on this crisis. Food could be made more healthy or healthy alternatives could be more available to consumers. Also, regulations could be made so there is a tax on unhealthy foods or a ban on commercials for them like with tobacco.

## **Power outages<sup>12 13</sup>**

When there are heavy storms, power lines can sometimes get damaged and cause blackouts, meaning there are periods in which a whole cluster of houses have no electricity until it gets fixed. During this time, any and all electrical lines and outlets might be dangerous. On top of that, power surges might kill any electrical devices that are still connected, and you no longer have access to a working refrigerator, gas and ovens.

## **Too much screen time<sup>14 15</sup>**

Pretty much everyone with a phone is using it too much, and it causes a lot of problems. Such as: nearsightedness, neck and back problems from bad posture, sleep deprivation, higher risk on obesity, diabetes and other chronic health diseases, concentration issues, degradation of social skills and emotional judgement, delayed learning and a poor self-esteem. The biggest source of screen time is social media, because it is very addicting.

## **Availability of first aid in public spaces**

If you're in a shopping center and you have a minor injury, chances are you're just going to have to wait until you get home to address it. Yes, all workspaces are forced by law to have a first aid kit, but only for their employees, and so you'll have a hard time getting your hands on a bandaid to use if you aren't at your own house.

(there should be vending machines or other places where you can buy bandaids and painkillers and other similar stuff at your convenience instead of having to go home)

## **Environmental pollution & Waste**

### **Kinds of environmental pollution caused by waste?<sup>16</sup>**

- Air pollution: contamination of air by smoke particles and harmful gasses, mainly oxides of carbon, nitrogen, and sulfur
- **Land pollution:** caused by improper disposal of waste and misuse of resources

Examples:

- Litter
- Oil spills

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- Illegal dumping in natural habitats
- Pesticides and other farming chemicals
- Nuclear accidents, radiation spills
- Garbage pollution: mismanagement of solid waste from human & their activities, waste collectors and waste disposal contractors -> spread of harmful bacteria, contamination of water -> transmission of parasites and bacteria to humans
- Beach pollution: waste, such as plastic bags, nets, or cigarette filters that is being thrown to the beach -> harms sea creatures, affects the marine environment.
- **Plastic pollution:** hard/soft non-biodegradable plastic, stays on the land for thousands of years or forever

## **How much waste do we produce:**

In 2013, in the Netherlands alone, each person produced 1.5kg of waste a day, which sums up to about 500kg of waste a year.<sup>17</sup>

Compared to what we produced in 2018/2019, which is approximately almost 490kg of waste per person a year, we have definitely slightly improved.<sup>18</sup>

## **The public sector, in particular Supermarkets and/or Restaurants:**

### **Receipts:**

Especially in Germany the amount of waste is doomed to increase, due to the “Belegausgabepflicht”, a policy that was implemented in January 2020. The policy indicated that every taxable entrepreneur must issue a receipt. Before September 2020, a company that didn't comply didn't have to pay any fines, but they did have to deal with more frequent audits and therefore tax payments<sup>19</sup>. However, as of September 2020, not complying with the policy can lead to high fines, leading up to 25,000 euros<sup>20</sup>.

The receipt must always be issued, it is not enough to simply ask the customer whether they would like one. The customer is free to do whatever they want with the receipt, they can reject it (in that case the entrepreneur throws the receipt in the trash), or take it with them or throw it away themselves. Although it is possible to send receipts electronically via app or e-mail, as of yet, there are no considerable practical solutions for that<sup>19</sup>.

## **HEALTH: Motivate people to be healthy during quarantine/ a Lockdown**

### **Activities:**<sup>21</sup>

There is an abundance of workout routines and diet plans on the internet. One that particularly stood out to me was a 14 days workout plan. Every workout day is named a quarantine workout pun, e.g. day2: “anti-covid-abs”, day 12: “Not out of stock tights”,...

Furthermore, the 152 comments seemed overwhelmingly positive.

A common theme with these activities and those of other fitness instructors is that consists of general workout activities that be done from home.

### **How to keep being motivated:**<sup>22</sup>

#### **Regular routine changes:**

E.g. by changing the order in which tasks are completed, and perhaps even taking a different approach to completing them. By taking sufficient breaks, and having a change of scenery.

#### **Organizing your Life:**

This aspects includes cleaning and organizing the things that surround you. Having a cleanout by for example moving unused items to an attic, shed or storage unit enables people to enjoy their spaces and feeling less weight down.

#### **Listing goals:**



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Making a clear list of goals to accomplish each day will ensure people to stay on track, boost momentum and amplify motivation.

## **Counting achievements:**

Having people look back on the things they have accomplished and giving themselves a pat on the back is a great way to motivate them to continue moving forward. This can even be just the fact that they stayed at home, as it helped reduce the spread of the virus.

## **FOOD INSECURITY**

### **Definition:**

Lack of consistent access to enough food for an active and healthy life, this can among others be due to financial constraints, or lack of food available in the area.

### **Cause: Financial Constrains:**

Who are the people who don't have enough money for food?<sup>23</sup>

Taking Germany as an example, we will be looking at the people who regularly visit 'die Tafeln', a German food bank chain. Almost half of the users live off of Harz IV (an unemployment and welfare package, that give money to those who are in need of assistance, more specifically if they can't provide their own living from their income, assets, or with the help of a relative), ¼ of the users are senior citizens, other visitors are low-wage earners, and single parents.

What's especially noticeable is the recent increase of senior users: in the last months there was a 20% increase compared to the previous year. In fact, a low pension payment is the second largest reason names why people visit the Tafel. More than one million people in Germany receive 'Grundsicherung' – basic income support.

Basic income support is a form of social assistance that pensioners and people with a reduction in earning capacity receive if they cannot make ends meet with their pension. Statistically, more than 566,000 citizens over the age of 65 are a case for social assistance for financial reasons. They are often low-income earners, long-term unemployed or failed self-employed persons. But these are only the official figures. Many pensioners shy away from going to the authorities - for the unjustified fear that the authorities might get the money back from their children.

<https://youtu.be/OxtlDZ1b4Lw>

**Example:** the increase in users of the 'Tafeln', a German food bank.<sup>24</sup>

For 26 years the Tafeln give out food, that would be otherwise thrown away, to the people with low income.

According to Stefan Selke, a sociologist, who studied poverty since 2003, the 'Tafeln' aren't a part of the solution to fight poverty, but actually a part of the problem. He states, that it is a shame that the food bank has existed for so long, and that their goal should be to make themselves obsolete, to path a way towards a serious discussion on how to achieve a society, where everyone can live a satisfying life.

The price people pay for visiting the 'Tafel' is the feeling of being on the fringes of society, especially in regards to one's social status, which is why a lot of users hide the fact they visit the foodbank. (and also 1,80euro for approximately 3 full bags) A prominent issue is, therefore, that a lot of people who need to use the food back either don't go because they feel ashamed, or because they are unaware that their income is low enough to register.

### **Cause: Insufficient supply**<sup>25</sup>

Famines are acute food crises following droughts or due to armed conflicts and are the worst form of food shortage. In addition to the elderly, babies and small children are particularly at risk of starvation.

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According to the UN definition (Integrated Food Security Phase Classification), a famine exists if there is at least:

- 20 percent of households suffer from extreme food shortages,
- 30 percent of the population is acutely malnourished,
- two out of 10,000 people or four children die daily from food shortages

## UNEMPLOYMENT: causes, and consequences<sup>26</sup>

According to Karl Marx, unemployment originates from “Konkurrenz der Maschinerie, Wechsel in der Qualität der angewandten Arbeiter, partiellen und allgemeinen Krisen” (Das Kapital) Translated, this means that unemployment originates from the competition of the machinery, changes in the quality of the applied workers, partial and general crises.

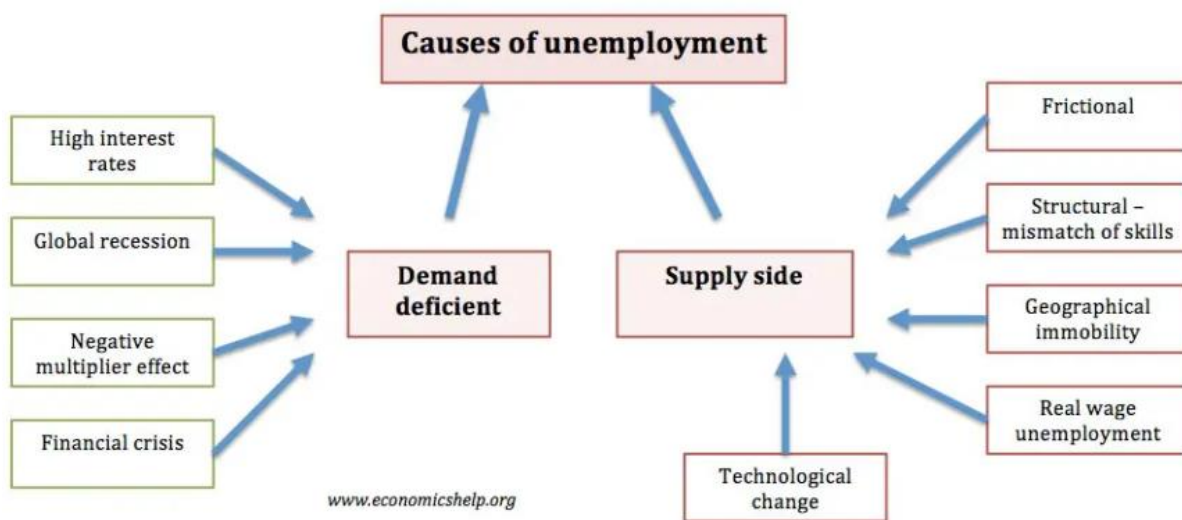


Figure 1 A graph used for the research on unemployment in Germany.

## Types of unemployment:<sup>27</sup>

### **Frictional Unemployment**

caused by the time people take to move between jobs, e.g. graduates or people changing jobs

### **Structural unemployment**

Occurs due to mismatch of skills in the labour market and can be caused by:

- **Occupational immobilities:** refers to the difficulties in learning new skills applicable to a new industry, and technological change, e.g. an unemployed farmer may struggle to find work in high tech industries.
- **Geographical immobilities:** refers to the difficulty in moving regions to get a job, e.g. there may be jobs in London, but it could be difficult to find suitable accommodation or schooling for their children.
- **Technological change:** If there is the development of labour-saving technology in some industries, then there will be a fall in demand for some types of labour which have been replaced by machines.
- **Structural change in the economy:** The decline of the coal mines due to a lack of competitiveness meant that many coal miners were unemployed. However, they found it difficult to get jobs in new industries such as computers.

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## **Classical or real-wage unemployment**

Occurs when wages in a competitive labour market are pushed above the equilibrium. Wages could be pushed above the equilibrium level by minimum wages or trades unions. This is sometimes known as “disequilibrium” unemployment.

## **Voluntary unemployment**

occurs when people choose to remain unemployed rather than take jobs available. Either due to welfare or frictional unemployment (choosing to wait until they find a better job)

## **Demand deficient or “Cyclical unemployment”**

Occurs when the economy is below full capacity. With a fall in output, firms will employ fewer workers because they are producing fewer goods. Also, some firms will go out of business leading to large scale redundancies. In recessions, unemployment tends to rise rapidly as firms lay off workers.

## **Importing food <sup>28</sup>**

Achieving global environmental sustainability and food security is among the world’s biggest challenges. International food trade plays an important role in global food security but there is an urgent need for innovative solutions to reduce environmental pollution and offset the negative impacts of international trade globally.

The biggest environmental problems caused by international food trade are water pollution, biodiversity loss and deforestation in the Amazon caused by soybean and grazing land expansion which are not even for human food production but for the Livestock feed.

Another problem with imported food is the loss in Nutrition. Fresh fruits and vegetables that are imported also need to be picked earlier. This leads to lower levels of vitamins, minerals and antioxidants.

It also increases the amount of waste while there is more packaging needed because the longer the journey the more chance of bruising and spoiling.

Food trade in numbers with Germany as an example:

1. Food imports that came by ship consume eleven times more energy and output eleven times more CO<sub>2</sub> than local products.
2. One Kg food that comes by plane causes 170 times as much emissions as one Kg food that comes on the seaway. That means that for one Kg food that comes by plane we could grow and transport 90 Kg of local food
3. If we would only import food that we can’t grow locally because of our climate we could save 22% of emissions.

## **Solution Urban Farming:**

In the year 2050 approximately 60% of the world population will live in urban areas. To provide enough food we must find solutions to grow crops in urban regions.

Forms of urban farming are vertical farming (in towers or old Industrial halls) rooftop farming and indoor farming with Hydroponic systems and LED light

## **Animal Cruelty<sup>29</sup>**

Animal cruelty occurs all over the world and every minute animals get abused.

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One problem is that animal abuse rarely occurs in plain view. It happens behind closed doors and in factory farms and often animals must suffer just because a person doesn't know how to properly care for that animal.

Another Problem is animal exploitation for example in circuses, zoos and aquatic theme parks where animals are forced to behave in an unnatural way for entertainment purposes. Circus animals for example spend 96 percent of their life in a cage when they're transported from city to city.

Also, the Human predation is a problem where animals get hunted just for the joy of the hunter in many cases even without the desire to eat them. Or the fur farming where a lot of cruelty happens even though we have the options of synthetic fur.

The biggest reason for animal suffers is probably in the livestock industry where animals have to live in cages without place to move or overfilled halls. The animal cruelty can involve debeaking, dehorning, castration without anesthetic, live plucking and more.

Factory farmed animals don't receive any more consideration than machine parts, they are viewed as objects. Farmers pack as many animals into a given space as possible, provide as little veterinary care as possible and use the animals as efficient as possible until they get slaughtered.

## **Surveillance and privacy<sup>30 31</sup>**

A life without the Internet and technology is unimaginable nowadays but the Internet has changed over the last decade from a free and decentralized and do-it-yourself internet to a centralized profit-oriented place. These days it's virtually impossible to not use the products of the major players (Microsoft, Google, Amazon, Apple, Facebook) which often come for "free". But this convenience comes at a price. The price you pay is Data, one of the main driving forces of the internet.

This data-centric world has and will continue to negatively impact the ability of freedom of individuals to exercise their freedom of speech and it will also increase cases of "data discrimination" in which oppressed or marginalized communities are further socially excluded due to non-transparent algorithmic processes.

These centralization, commercialization and datafication trends make it easier for governments and companies to engage in surveillance activities aimed at controlling, censoring and tracking down political dissents.

Censoring doesn't even need to be forced; one danger of overt surveillance is self-censorship. When people are aware that they are being watched, they tend to alter their behavior in a way to what they think to be "normal behavior" this self-censorship even occurs if a person is doing nothing wrong.

A major problem with the massive collection of private data is that everyone becomes easy to blackmail or suppressed because if watched long enough, any person may be caught in some form of illegal or immoral activity.

If we look at china, we can easily see what mass surveillance and loss of privacy can lead to. In the city of Rongcheng in Chinas east, every person is automatically given 1000 points, fighting with your neighbors will cost you 5 points, you don't clean up after your dog and you will lose 10. If you fall below a certain score it's impossible to get a loan or book a high-speed train ticket. If you get caught speaking against the CCP you must fear ending in a detention camp.

## Chapter 2: Identification of General Problems and Challenges

We picked the most interesting subjects from chapter 1 and did some extra research on them. We tried to identify some general problems and challenges if we were to choose the subject for the rest of the project.

### General problems and challenges:

#### Animal cruelty:

To stop animal cruelty, a large majority of the world would need to give up on eating meat, or at least on a daily basis. This is an incredibly hard challenge to overcome, as shown by the amount of money and effort that's already been put into it by now, and the effects it's had, being not a lot.

#### Healthcare during festivals:

Since space is very limited at festivals, many possible solutions to the problem of medical stations take up too much space, fall flat. This combined with the high amount of alcohol intake, the first aid people are very understaffed at the festivals due to the sheer amount of demand.

#### Pollution:

Mismanagement of waste is a big problem. A lack of waste management infrastructure in third world countries results in tons of waste being deposited in rivers. This leads to polluted water supplies and it is a danger to the people and animals living in/near it. Furthermore, all this waste makes its way to the ocean where it is also a big problem. Animals die trapped in plastic or with big amounts of plastic in their body. Also, the plastic degrades into smaller particles, which are eaten by marine life and make their way up the food chain, eventually to humans.

#### Global obesity

19% of the adult world population is obese (2016), this is a problem because it leads to serious health risks. These include but are not limited to cardiovascular diseases, diabetes, musculoskeletal disorders and some variations of cancer. This problem is getting worse by the year, with more people suffering from it every day.

#### Climate change

There is indisputable evidence that climate change is a real thing, that it is caused by humans and that the consequences are severe. With the amount of greenhouse gasses that are dumped into the atmosphere yearly, the earth is getting warmer. This is unsustainable because this causes sea levels to rise, climate to change and natural disasters to become worse.

#### Waste - German Supermarkets:

German supermarkets are considerably more Low-Tech than Dutch ones: Especially in small towns, they don't have self-checkout, no devices to scan the products yourself, and in most cases inventory is still done by hand (meaning that they count every product).

in most cases inventory is still being counted by hand

Furthermore, as of January 2020, Germany has a new policy called "Belegausgabepflicht" – which indicates that every taxable entrepreneur **must** issue a receipt. This often results in waste as most users decline, meaning it is thrown away at the store, or users take it with them to throw it out themselves.

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It is possible to issue receipts electronically, i.e., via app or e-mail. However as of yet, there are no considerable practical solutions for that.

## **Importing food**

Problems of food imports are water pollution because of fertilizers and pesticides that go into the water and the emissions from cargo ships. Importing food also means a lot of carbon emissions by planes and ships that transport food over long distances. Another problem is deforestation to expand agricultural land. All the mentioned problems directly relate to climate change and the loss of biodiversity. Another factor is the loss in Nutrition because the vegs and fruits must get picked when they are not ripe. Food imports also need more plastic packaging for the long journey.

## **Sleep deprivation**

When people sleep less they become way less efficient and become pretty much useless. In a society like the one we have today, you cannot be less valuable because you can easily be replaced. Being the best you, you can be is very important.

## **Gaming addiction**

Gaming constantly will have a great effect on the mind and body. Your mental health might decline rapidly. You might form depression, or another mental illness. By constantly sitting, and not moving, you might gain a lot of weight, maybe even become obese. Or on the other side of the spectrum, you could lose an excessive amount of weight by forgetting to eat.

## **Campus isolation (social-less-ness)**

By being isolated from your peers your mental health might decline and you can't discover who you are. Since the quarantine the rates of suicides have gone up quite a bit. Also, students are way less motivated for their studies as there is way less interactivity as almost everything is canceled.

## **Too much screen time**

Causes a myriad of health problems such as: nearsightedness, neck and back problems from bad posture, sleep deprivation, higher risk on obesity, diabetes and other chronic health diseases, concentration issues, degradation of social skills and emotional judgement, delayed learning and a poor self-esteem.

## Chapter 3: Identification of Relevant Problems

In this chapter, we took a critical look at each of our topics in chapter 2. We combined some topics that related to each other, ensured that the topics were specific enough to enlarge on, and of course kept the relevancy and urgency of the topics in mind.

### **Too much screen time**

This subject is very relevant at the moment, in the quarantine everything shifted to online. Work, school, and even leisure time activities are moved from physical to online. But also, before the quarantine there was a large number of people being online more often than not.

### **Gaming Addiction**

Most children nowadays grow up playing video games. This in itself is very harmless, however it could lead to gaming addiction. This is why this problem is very relevant today, but will be even more relevant in the future. Because gaming addiction is often misunderstood, it has not been addressed effectively yet.

### **Sleep deprivation**

Sleep deprivation happens in every country and every business. It makes people less productive, grumpy, and temporarily degrades your cognitive abilities. With sleep deprivation being a large problem for decennia, we can safely say that it has not been addressed properly.

### **German supermarkets**

The issue of the “Belegausgabepflicht” is relevant, not only because it was implemented in January 2020 and punishable as of September 2020, but also because printing unnecessary receipts leads to harming the environment even more. As mentioned in the German article we sourced, it is possible to send out the receipts electronically, however, as of yet no considerable practical solutions exist. The problem can be considered urgent, as any means to slow down global warming is a measure that should be taken into consideration.

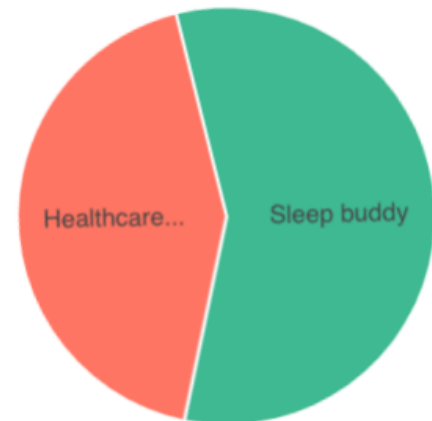
### **Health care/Smart Environments at Festivals**

Healthcare and smart environments at festivals

Unfortunately, there are no festivals in the Covid time, but that gives great opportunities to develop new concepts. A specific problem we recognized is the shortage of quick healthcare at festivals. Often injured people are hard to reach in a big crowd, or if they have just minor accidents people don't have quick access to first aid materials like bandages. Another thing related to the Covid situation is the problem of keeping distance at festivals here could a smart environment help for example when you can see in an app how many people are already in front of the stage or the next food truck.

## Chapter 4: Problem Selection and Motivation

In chapter 3, we narrowed down all our ideas to a handful that we really liked. This was either because we found the problem interesting in order to pick a final topic, we decided to write down each challenge that every idea has and play advocate of the devil. This way we would obtain a realistic view of the difficulties of each topic, and we would be prepared for the possible downfalls. In the end, two topics stood out to us the most, as they were very realistic, considerably more fun and interesting for us to enlarge on! To make the final decision, we used a website called strawpoll.com to vote democratically which one of the ideas we would work out. Our idea of making a "sleepy buddy" to fight the issue of sleep deprivation, won by one vote!



*Figure 2 | close call democratic decision that would determine the future of our project*

The reason why we choose to tackle the issue of sleep deprivation is that as students we know all about it. Having experienced it ourselves and knowing people who suffer from it also allows us to have a broad audience we can survey. Furthermore, we are certain that we can therefore develop something that can be of help to a broad audience of people. Suffering from sleep deprivation comes with a lot of burdens, such as moodiness, a loss of productiveness, and the degradation of cognitive abilities. Additionally, whilst brainstorming we already came up with a bunch of ideas to fight against this disaster. During sketching, we already brought some of these ideas into concepts. We are all equally motivated to work on it!

Our presentation: [https://universiteitwente-my.sharepoint.com/:p:/r/personal/l\\_vandergalien\\_student\\_utwente\\_nl/Documents/Presentation%201.pptx?d=w306f217462fd458a940ed6dc73c0312c&csf=1&web=1&e=gBiYsG](https://universiteitwente-my.sharepoint.com/:p:/r/personal/l_vandergalien_student_utwente_nl/Documents/Presentation%201.pptx?d=w306f217462fd458a940ed6dc73c0312c&csf=1&web=1&e=gBiYsG)<sup>32</sup>



## Chapter 5: Potential Solutions

For this chapter, we thought about some potential or existing solutions to our 'disaster'. We found multiple studies giving insight to the causes of sleep deprivation. We summarized all the studies that we found and made a list of possible solutions to the problem. We want to use as much of these solutions in our final product.

### **Solution 1: Sounds (alarm)**

The Impact of the ringtone sound of an alarm<sup>33</sup>

In a study, fifty participants were asked to make a sleep journal and to use different ringtones. The result was that people who used softer ringtones were less tired during the day than those who used shrill sounds.

Scientists at the RMIT University suppose that shrill wake-up tones could disturb brain activity even if a person slept enough hours.

Something that has been studied and found to be effective is dawn simulating alarm clocks. The use of these lamps increases cortisol levels in the morning and that prepares the brain and body for the stressors of the day.

So, the best is probably to use a soft and slowly in volume increasing alarm like some ambient sound in combination with light.

### **Solution 2: Light (anti-Blue light/wakeup light)**

As a response to low light levels, the brain starts the production of melatonin, however bright lights slow and even halt that production. Blue light specifically, whether from the sun or a laptop, is very effective at inhibiting melatonin production. Drowsiness increases with rising melatonin levels. So having controlled lights that take into account the expected sleep time and lower their brightness and blue light levels to increase drowsiness would help getting to fall asleep faster.

Another factor of light related to sleep is waking up with a light. The very same light receptors your eyes use to say that it's nighttime, and thus time to sleep, are also used for daytime. Having lights instead of an alarm tricks the brain into thinking it's daytime. This makes it easier for the brain to accept that it is time to be awake and feel more refreshed.

### **Solution 3: Vibrations**

Feeling tired is not only about the amount of sleep you get but also the way you wake up. There are many different solutions to this. Some people like waking up to music, others to light. One method that is not as common on the current market is vibrations. This can be done in many ways, the most convenient of which is in the form of a smart watch or bracelet. The easiest way to create vibrations in an electronic product is through the use of a vibration motor. This is usually a small dc motor with a rotating mass attached. Another way to do this is with an electromagnet and a sliding mass. If this motor or electromagnet is controlled properly, this could feel like a light tap on the wrist, slowly increasing its intensity until the user wakes up.

A product like a smart watch or bracelet could also easily track sleep cycles by measuring the user's heartrate and movement, since it is already in contact with the body. The sleep cycle is the cycle of phases the body goes through while asleep. Waking up in the right phase makes the user feel more active and refreshed. By tracking these cycles, in theory, the device could estimate at what time within a specified window it is best to wake up the user. This combined with the comfortable feeling

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of waking up by vibrations instead of an annoying alarm sound could really improve the user's sleep quality.

## **Solution 4: Aroma**

There have been many studies about sleep, and the loss of it. Aroma therapy is one of the subjects of it. Aroma has been proven to be very effective against fatigue, and it improves the quality of sleep. Lavender has even been proven to help with sleeping disorders.

We could try to decrease sleep deprivation by releasing specific aromas to help get the person in the mood for sleeping.

This could be done by making a small desktop/nightstand electronic device, powered by an Arduino, that releases aromas a couple of minutes before your set bedtime. This way people will get sleepy, or at least, in the mood for sleeping. It could also release aromas, not only for decreasing wakefulness, but also stress decreasing. This way they might get less stressed, which is often a big factor in sleep deprivation.



*Figure 3 A nice visualization of lavender*

## **Solution 5: App (Monitor the causes of sleep deprivation throughout the day -- caffeine, alcohol, nicotine, exercise)**

Sleep deprivation is being caused by numerous amounts of problems. It can be caused by e.g., an excessive caffeine intake, alcohol consumption, nicotine usage, a bad diet, lack of exercise, stress, poor sleep habits, etc. (cf. Harvard health publishing)

It is important to identify these issues and inform the user about them, so they can take initiative into their own hands and try to solve the problem by themselves using the tips we could give them. However, this feature of the app would only work when using it in combination with a smart device, such as a smart watch or smart wrist, that could monitor things like heartbeat which could then be analyzed by the app.

This App would be able detect a possible cause of the user's sleep deprivation, and can in return offer tips, a roadmap, or other things to help the user fight against the causes.

The app could also offer something that is being referred to in solution 7, by e.g., dimming the display brightness etc.

## **Solution 6: Breathing helper**

When being asleep your breathing pattern changes. It is being described that during non-REM sleep, which is approx. 80% of an adult's sleeping time, the breathing is lowly and regularly. During REM sleep (which is the dream part of a person's sleep) the breathing rate goes up. (cf. webmd)

In short, breathing slowly may help you fall asleep faster and transition into non-REM sleep. Furthermore, reminding and helping people to keep a slow and steady breathing pattern, can help them de-stress.

A solution utilizing this idea could be built upon breathing animations. These are short animations, usually GIF sized, that use simple movements to help you focus on it and breathe along with it. It works wonders for people with panic attacks to help them calm down, so perhaps using a similar concept here could work great. The only caveat is that having a screen present will absolutely *not* help you sleep, in fact it'll make things worse, so we'd need to build a device that builds on the same

concept but implements it differently. Perhaps with something that inflates and deflates, or varying degrees of pressure from a wristband.



Figure 4 An app that helps people with breathing

## Solution 7: Routines

Having a steady sleeping routine is a key factor in having a good night's sleep. A study in *Journal of Adolescent Health*<sup>34</sup> showed that over 60% of students had poor sleep quality according to the PSQI (Pittsburgh Sleep Quality Index). Most students perform better during the afternoon and are less productive in the morning, due to a lack of sleep. A solution for this problem could be to set a good sleeping routine for yourself, or to start work and school later. Since the latter is harder to implement, the first would be our focus during this project. There are already many phone applications and methods to force a better sleep schedule. Reminders for a set bedtime can be written on digital devices and rewards for sticking to a sleep schedule can be given. This would encourage people to go to bed earlier and thus sleep longer.

Having a good sleeping routine helps getting the recommended amount of sleep and will make you more energized during the day. Having a reminder to go to bed, possibly with a reward system, can encourage a good sleeping routine.

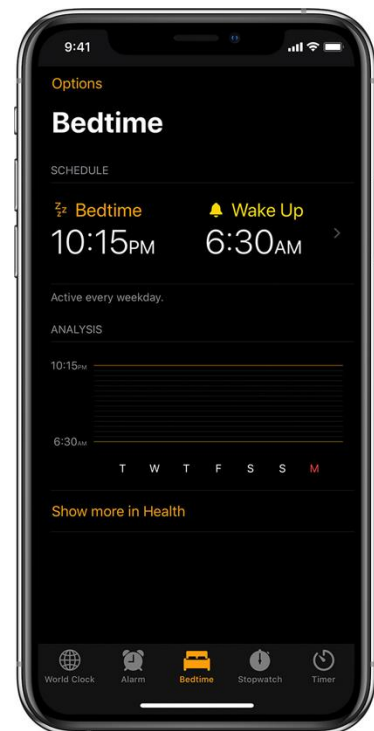


Figure 5 Apple's Bedtime app that helps you sleep

## Chapter 6: Solution Selection

For this chapter we decided on a solution to work on during the project, we explain the reason as to why we selected this solution and roughly divide the tasks amongst our members.

For our final solution we decided on working on a Sleeping Buddy. In a nutshell, this device is designed to improve the general sleeping experience of the user. The sleeping buddy would be a device they can go to sleep with. Depending on which design we are choosing it is either a comforting-looking plushie, or a more artistic piece that either stands on the user's nightstand or can maybe hang off the wall.

In the morning (at a set time) the user will be woken up by slowly increasing warm lighting, which imitates the rising sun and can trick the brain into believing it is morning (especially useful for people who have to wake up early). We will be using LED strips to achieve this goal.

The sleep buddy will also be able to play audio, which, as with all alarms, can successfully wake up the user. The audio will be output by a speaker, and can possibly alternate between alarm sounds, to avoid repetition.

The next and last feature we will be focusing on is aroma. Aroma will be spread around the physical room, probably, using a diffuser. The aroma that will be used is lavender, as that has been proven to help with sleeping disorders.

The reason as to why we have chosen the sleep buddy as our Smart Environment project is because it is a far more physical solution than the App solution would have been. The sleep buddy uses sensors and can affect/alter its surrounding. Furthermore, we believe that our sleep buddy will prove to be helpful as it contains many features that can help improve the quality of a user's sleep. Furthermore, subjectively speaking, we consider the sleep buddy to be a more appealing and innovative solution than the ones currently on the market (like a smartwatch e.g.)

A more ambitious plan would be to make a mobile app, which could work with (hopefully) any smartwatch. As there are already a lot of smartwatches on the market, we decided against the idea of introducing another one. Having just a mobile app in our Smart Environment project wouldn't be sufficient as it would just consist of software. Hence supporting our idea for the physical sleep buddy. If we, however, do find the time, we will try and work on an additional mobile app. That way we can fight sleep deprivation at its cause (and improve the general sleeping quality)

**TASK DIVISION** [Note: The first person is the one responsible for the task, the second person serves as an assistant/help]

Team Leading (Checking up on progress, helping where help is needed, and keeping track of time/deadlines):

- Lot

Theory Manager (Research our hypothesis, find concrete evidence for our solution):

- Reinier

Material planner (Ordering and taking care of necessary material and equipment):

- Ruben

Design (The design of our sleep buddy, concrete plans on how it's going to look like):

- Juno, Ruben

Programming (Physical computing using Arduino, maybe if enough time is available App development):

- Roos, Ruben, Lot

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Communication (finding test subjects) and Feedback (questioning the test subjects, surveys, etc.):

- Joell

Data analysis (Evaluate and visualize findings (feedback, etc.)):

- Reinier, Joell

Presentation and final demonstration (In charge of the final demo (aesthetic and functionality wise)):

- Juno, Reinier

## Chapter 7: Methodology

In this chapter we noted down our roughly noted down our methodology

### BASIC SCENARIO

An overview of the equipment we need / we used

Necessary Sensor	Purpose	Purchased Sensor (and where we purchased it)	Review
<b>Motion sensor</b>	Detect movement whilst "Sleep- Mode" is activated, conclusion on whether or not the user slept well will be taken from these measurements (A lot of movement -> bad sleep)	<ul style="list-style-type: none"> <li>Grove – Digital PIR Motion Sensor [SS-101020793]</li> <li>Grove – Ultrasonic Ranger [SS-101020010]</li> <li>Grove – PIR Motion Sensor [SS-101020020]</li> </ul>	We purposefully ordered multiple motion sensors, to test them and evaluate them, ultimately pick the best for our project. The one we ended up using was the PIR Motion Sensor, due to its precise movement detection. The ranger we ordered, just in case we would need one, but ended up not finding a use for it.
<b>Potentiometer</b>	Alter current time, wake up time (alarm time), and LED Brightness	We didn't purchase this sensor, one of our teammates already owned a well-functioning Potentiometer	/
<b>Buttons</b>	Enables Go to Sleep – mode and can turn off the alarm It can also be used to select individual settings, which can be altered with the potentiometer	<ul style="list-style-type: none"> <li>16mm Verlichte Drukknop - Tijdelijk - Wit [KW-2329]</li> <li>16mm Verlichte Drukknop - Tijdelijk - Rood [KW-2325]</li> </ul>	We, again, bought two just in case of of them wouldn't work. We ended up choosing the red button, as it has a more distinctive color

Necessary Actuators	Purpose	Purchased Actuator (and where we purchased it)	Review
<b>Display</b>	Allows the user to see the current time, alarm time, and LED Brightness	We didn't purchase this actuator, we used a the display one of our teammate's owned	/
<b>Diffuser</b>	To diffuse aroma throughout the room, before going to bed –	Aroma Diffuser - Luchtbevochtiger Aroma Therapie + NEUTRIHERBS	It works well, it distributes the essential oil really well.

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	should help falling asleep	Olie 10 ML - Vernevelaar – Verstuiver – Lichtbruin	Unfortunately, it doesn't function remotely though, as the ones that did, were too expensive and didn't fit into the budget
<b>Speaker</b>	Outputs the alarm to wake the user up	Borrowed from SmartXP	Works well as well
<b>Speaker Module</b>	Necessary to use with the Speaker	Seriële MP3 Player module JQ6500 met geheugenchip en speakeruitgang	Necessary to use with the speaker, it works well.
<b>LED Strips</b>	Will wake up the user with warm lighting (The brightness can be changed)	We used an LED strip one of our team members had laying around	/
<b>Servo</b>	Enables the Diffuser	We all had a Servo in the Protokit, so we used that one	For the prototype, it works. If this project ever goes professional though, it should be done with an remote controlled diffuser.

The environment our product is going to be used in is a bedroom, which is controlled. Data collection will be done a surveys and directly asking for feedback

We will be using this data and visualize it with the help of existing software.

Due to the lengthiness of testing and the lockdown restrictions, we decided to limit our testing's on just one person. In order to fully test out our product we test it out over the course of several days. We at least have to test out our product twice, once without all our features on and once with all of our features activated to know how the user usually sleeps and see if our features actually improve anything.

## **AMBITIOUS**

If we have enough time for the app development, we plan on using the android studio IDE with the flutter plugin. The IDE enables us USB debugging (allowing us to quickly test the app using our own android device). Using flutter allows the app to be cross-platform. If we are not mistaken, smartwatch software can also be programmed using the IDE, but we'll look more into it when the time comes.

Furthermore, in order for the APP to be functional, we would need to either make a smart watch/bracelet or ensure that it is compatible with an abundance of bracelets currently on the market.

## Chapter 8: Results and Conclusion

### Chapter 8.1: Theoretical Conclusion

Upon waiting for the test results to be complete, we decided to look up papers, and research online that would confirm or even deny the individual features of our product.

The disaster in current society known as sleep issues is very relevant, where [at least one in four people](#)<sup>35</sup> acknowledge it with way more unaware. The Sleep Buddy aims to raise awareness on top of using multiple methods to improve the sleep quality of the user.

The movement sensor embedded in the Sleep Buddy can measure sleep duration by sensing the time when you are inactive at night time. This allows it to roughly measure the amount of sleep a user gets every night.

The Sleep Buddy also tracks the activity present during sleep. This measures the quality of sleep a user is getting by the amount of movement that is sensed during the night. The Sleep Buddy assumes that sleep is the only thing happening in bed, so any other activity will be measured as part of a bad sleep.

Both of those capabilities allow for information to be processed into a friendly way of showing the information. This allows users to reflect upon their sleep and gain insights into what may be a bad sleep routine. According to the [American Academy of Sleep Medicine](#), there is a definite response of patients using sleep trackers taking action and seeking help/treatment due to these trackers sensing poor sleeping habits. And according to Alan Schwartz at Johns Hopkins Bayview Medical Center, even though sleep trackers don't measure sleep directly, they will give you something to reflect on, just take the numbers with a grain of salt.

There is also a diffuser with lavender scent present in the Sleep Buddy to improve sleep quality of sleep for the user. According to the Journal of Alternative and Complementary Medicine, the inhalation of lavender essential oil at night had a [real improvement in sleep quality](#) for the tested audience (being college students with self-reported sleep issues).

Inside of the Sleep Buddy there are LEDs that will turn on in the morning and be used as a form of wake up alarm. It has been [proven that using light to wake up](#) to increase cortisol levels, allowing the user a more pleasant and refreshed wake up experience.

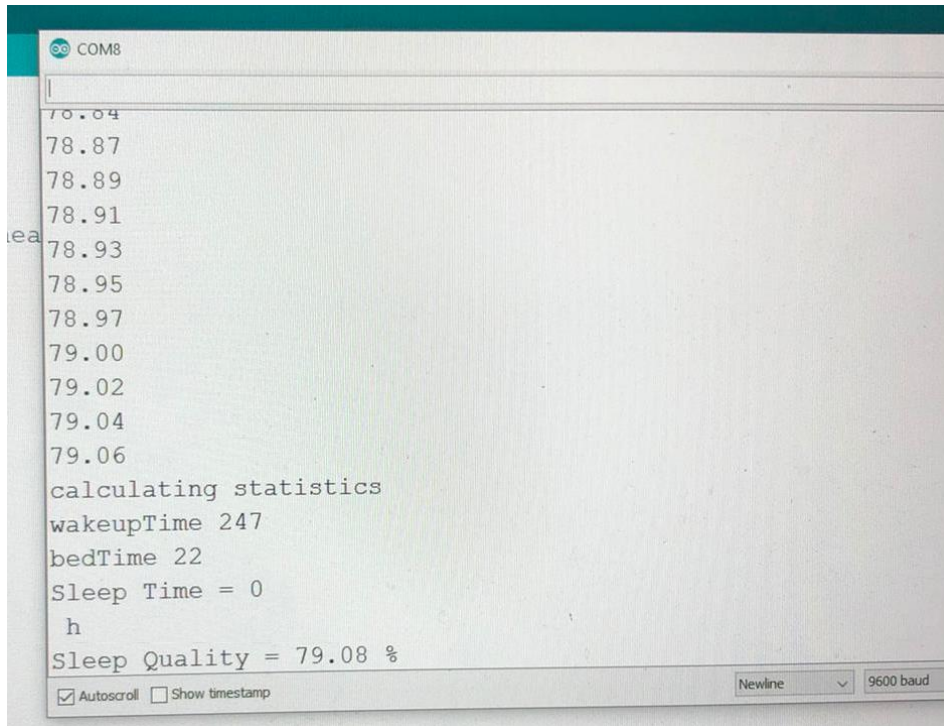
For decades people have woken up using an alarm clock. This proves its effectiveness has been thoroughly proven over this time. In order to take advantage of this, the Sleep Buddy also has a wake up alarm embedded within it.

The first step in improving someone's sleep, making the users aware, can be solved through the movement sensor's data. The second step is acting. This is done in the form of a lavender scented diffuser, a wake up light, and alarm clock. Thus the Sleep Buddy covers both the making aware of poor sleep habits, as well as actually improving the quality of sleep the user is getting.

### Chapter 8.2: Conclusion taken from test results

In order to test our product we have used it whilst taking a powernap and had the following result:





```
COM8
78.84
78.87
78.89
78.91
78.93
78.95
78.97
79.00
79.02
79.04
79.06
calculating statistics
wakeupTime 247
bedTime 22
Sleep Time = 0
h
Sleep Quality = 79.08 %
 Autoscroll  Show timestamp
Newline 9600 baud
```

Figure 6: Test results after some sleep

To clarify, the statistics important to the client is the sleep time and the sleep quality, hence why we will enlarge on those two factors. The sleep time consists of a rounded number of hours the client has slept. As a powernap takes approximately 15 to 20 minutes, the sleep time is rounded down to zero.

The sleep quality is a percentage, that indicates how well the user has slept. As we specified before, the how well the user has slept depends on how little the user has moved during their sleep. A lot of movement would therefore translate to bad sleep. In this case, the higher the percentage, the less the user has moved, and therefore the higher their sleep quality must have been.

While we were still working on evaluating the sensor values, we have tested the product for a few nights, to see if users would find the features to be pleasant. From the feedback we have received, we could notice a positive response to the LED strip lighting. Our test person has said that the lights were an effective and pleasant way of waking them up. As it slowly became more bright, it was perceived as a gentle way of waking, whilst still being effective due to the brightness it could achieve in the end. The diffuser, which turns on right as you set your bed time alarm, also received positive feedback. Our test person could smell the difference, and found the lavender to be pleasant. Whether or not it helped them fall asleep sooner, couldn't be evaluated, as it was difficult for the user to pinpoint an exact time they fell asleep.

The only thing that wasn't perceived as pleasant was the alarm. In order to debug (and test) the product we have selected a loud and prominent alarm, which was a rooster alarm ringtone. We originally planned on using a more delightful and calming alarm tone, but forgot to change it, hence why this feature of the product couldn't be evaluated properly.

Overall, we, as a team, really liked the way our product turned out. Especially the user interface, which makes it easy for the user to change the time, alarm, and settings. As we mentioned in previous versions of our documentation, we originally wanted to test the product more extensively, which unfortunately, due to lockdown restrictions, became difficult to do. However, from the results and evaluation we got from our client, we can see that the Sleeping Buddy had indeed been perceived as pleasant and preferable (at least to that person)

## Chapter 9: literature

### Chapter 0:

A short article about the current problem with sleep deprivation among students.

<sup>1</sup><https://www.healthline.com/health-news/73-of-high-school-students-dont-get-enough-sleep#:~:text=Research%20has%20found%20that%2073,a%20healthy%20amount%20of%20sleep.>

### Chapter 1:

Small town monopolies:

<sup>2</sup><https://willconkwright.com/the-dilemma-of-the-small-town-monopoly/>

Cow abuse:

<sup>3</sup><https://www.change.org/p/dairy-farmers-of-america-stop-the-cruelty-shift-to-vegan-milk>

Internet down survival pack:

<sup>4</sup><https://www.bbc.com/news/world-asia-china-49317695>

Sleep deprivation:

<sup>5</sup><https://academic.oup.com/sleep/article/26/2/117/2709164>

Coral Death:

<sup>6</sup><https://www.sciencedirect.com/science/article/pii/S0006320703003951>

<sup>7</sup><https://psycnet.apa.org/fulltext/2020-66840-001.html>

<sup>8</sup><https://www.tandfonline.com/doi/full/10.1080/01926180902942191>

<sup>9</sup><https://climate.nasa.gov/solutions/adaptation-mitigation/>

<sup>10</sup><https://ourworldindata.org/plastic-pollution>

<sup>11</sup><https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight>

<sup>12</sup><https://safeelectricity.org/help-get-power-outage-storm-kit-prepared/>

<sup>13</sup><https://www.ready.gov/power-outages>

<sup>14</sup><https://www.activehealth.sg/read/screen-time/what-are-the-negative-side-effects-of-too-much-screen-time>

<sup>15</sup><https://www.inc.com/jonathan-steiman/i-reduced-my-screen-time-by-50-percent-it-wasnt-that-hard-heres-how-i-did-it.html>

<sup>16</sup><https://waste4change.com/blog/5-kinds-of-environmental-pollution-caused-by-waste>

<sup>17</sup><https://www.assises-dechets.org/fr/10-assises-2013/interviews/22-succes-du-recyclage-au-pays-bas-analyse-wilma-mansveld>

<sup>18</sup>[2]<https://www.milieucentraal.nl/minder-afval/afval-scheiden-cijfers-en-kilos/>

<sup>19</sup><https://www.kassensystemevergleich.de/belegausgabepflicht-ab-2020-was-ist-zu-beachten/>[1]

<sup>20</sup><https://www.orderbird.com/blog/belegausgabepflicht/>[2]

<sup>21</sup><https://www.blogilates.com/14-day-quarantine-workout-plan/>

<sup>22</sup><https://www.workforgood.org/article/7-ways-to-stay-motivated-during-the-quarantine/>

<sup>23</sup>[https://www.tagesspiegel.de/politik/armes-deutschland-warum-immer-mehr-menschen-zu-den-tafeln-muessen/25029964.html?utm\\_campaign=Morgenlage\\_politik&utm\\_medium=Email&utm\\_source=Tagesspiegel\\_Newsletter](https://www.tagesspiegel.de/politik/armes-deutschland-warum-immer-mehr-menschen-zu-den-tafeln-muessen/25029964.html?utm_campaign=Morgenlage_politik&utm_medium=Email&utm_source=Tagesspiegel_Newsletter)

<sup>24</sup>[Kein Geld für'n Supermarkt - Der schwere Gang zur Tafel \[DOKU/2018/HD\]](#)

<sup>25</sup><https://www.sos-kinderdoerfer.de/informieren/wo-wir-helfen/afrika/hunger-in-afrika#:~:text=Als%20Untergrenze%20werden%20durchschnittlich%201800,s%C3%BCdlich%20der%20Sahara%20gelegenen%20Staaten.>

<sup>26</sup><https://moien.lu/wp-content/uploads/2020/01/Das-Kapital-Karl-Marx-Band-1.pdf>

<sup>27</sup><https://www.economicshelp.org/macroeconomics/unemployment/causes/>

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<sup>28</sup> <https://www.pnas.org/content/115/21/5415>

<sup>29</sup> <https://sentientmedia.org/animal-cruelty/>

<sup>30</sup> <https://www.economist.com?open-future/2019/12/13/surveillance-is-a-fact-of-life-so-make-privacy-a-human-right>

<sup>31</sup> <https://time.com/5735411/china-surveillance-privacy-issues/>

Chapter 4:

<sup>32</sup> [https://universiteitwente-](https://universiteitwente-my.sharepoint.com/:p:/r/personal/l_vandergalien_student_utwente_nl/Documents/Presentation%201.pptx?d=w306f217462fd458a940ed6dc73c0312c&csf=1&web=1&e=gBiYsG)

[my.sharepoint.com/:p:/r/personal/l\\_vandergalien\\_student\\_utwente\\_nl/Documents/Presentation%201.pptx?d=w306f217462fd458a940ed6dc73c0312c&csf=1&web=1&e=gBiYsG](https://universiteitwente-my.sharepoint.com/:p:/r/personal/l_vandergalien_student_utwente_nl/Documents/Presentation%201.pptx?d=w306f217462fd458a940ed6dc73c0312c&csf=1&web=1&e=gBiYsG)

Chapter 5:

<sup>33</sup> <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0215788>

<sup>34</sup> Journal of Adolescent Health ([Volume 46, Issue 2](#), February 2010, Pages 124-13)

Chapter 8:

<sup>35</sup> <https://www.hopkinsmedicine.org/health/wellness-and-prevention/do-sleep-trackers-really-work>

<sup>36</sup> <https://www.alaskasleep.com/blog/insights-into-insomnia-that-will-improve-your-sleep>

<sup>37</sup> <https://www.hopkinsmedicine.org/pulmonary/sleep-medicine/>

<sup>38</sup> <https://pubmed.ncbi.nlm.nih.gov/27855740/>

<sup>39</sup> <https://www.nosleeplessnights.com/does-lavender-help-you-sleep/>

<sup>40</sup> <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4505755/>

<sup>41</sup> <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.456.9753&rep=rep1&type=pdf#page=107>