

CREATING A SUSTAINABLE MOBILE PHONE ENVIRONMENT:

OPPORTUNITIES AND CHALLENGES IN INTERACTION DESIGN

Bachelor Thesis in computer science

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Zürich, 31.03.2017

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ACKNOWLEDGEMENTS

First, I would like to thank my advisor Elaine Huang for supporting me in this project. Second, I give many thanks to Helen Ai He, Christian Remy and Gunnar Harboe which have all helped me much in various stages of the project. Lastly, I thank all the participants who have taken part in the survey and interviews.

ABSTRACT

In sustainable HCI there are many challenges, one of them being the sustainability of mobile phones and how to improve it with interaction design. To address this, a survey and interviews were made to qualitatively study the use, ownership, disposal, replacement, and value of mobile phones. Additionally, this follows up on a paper published in 2008[5] that had a similar topic and comparisons are drawn to identify the changes in the past years. The findings show many opportunities and challenges which are addressed in a discussion where new ideas are proposed and other opportunities are outlined to give ideas for implementations and future work.

ZUSAMMENFASSUNG

Im Bereich nachhaltiger HCI gibt es viele Herausforderungen, eine davon ist die Nachhaltigkeit von Mobiltelefonen und wie man Interaktionsdesign benutzen kann um diese Lage zu verbessern. Um dies anzusprechen, wurden eine Umfrage sowie Interviews gemacht um qualitativ die Benutzung, Beseitigung, den Austausch, Besitz und Wert von Mobiltelefonen zu untersuchen. Diese Arbeit folgt einer Publikation von 2008 [5] mit einem ähnlichen Thema und Vergleiche werden gezogen um Veränderungen in vergangenen Jahren zu identifizieren. Die Erkenntnisse zeigen einige Gelegenheiten sowie Herausforderungen auf, die in einer Diskussion adressiert werden wo neue Ideen vorgeschlagen werden um Ideen für Umsetzungen oder künftige Arbeit zu schaffen.

INTRODUCTION

Electronic devices have become a part of our everyday life in the past years. They are made use of daily and it's hard to imagine a life without them. Especially mobile phones have an enormous impact and are widely used all around the world. They offer a wide amount of functions such as communication, entertainment, productivity and much more.

Due to the importance of mobile phones in society and the business world, they are sold in extreme amounts. According to a report From Gartner, alone in 2015 around 1.5 billion devices have been sold. Even though, the growth was smallest since 2008 [1], it is still an enormous number of units sold, considering the world population is around 7.5 billion [2].

In emerging countries, the possession of a smartphone is becoming more common as stated in an article, "smartphone ownership rates in emerging and developing nations are rising at an extraordinary rate, climbing from a median of 21% in 2013 to 37% in 2015". [3] This further fuels the market for mobile phones and thus the number of mobile phones sold per year is not likely to decline.

This extreme consumption inevitably leads to waste. Especially mobile phones and can be very damaging with the components they contain as Fishbein [4] showed. Compared to other electronic devices they have a very short product cycle and thus generate more waste every year. This waste needs to be handled somehow but often the phones are stored in homes for a while and find their way to landfills. The export to developing countries of old phones is also not always a good thing, since they end up with the barely functional devices and them must handle the toxic wastes.

Like many of the new electronic devices, mobile phones are not necessarily discarded when they are broken. Often, they are replaced because the phone contract ran out, the phone got slow or the battery life is fading. This means that in many cases, the mobile phones are still functional when they are replaced.

In 2008 Huang et al. [5] published a paper on investigating the use, lifespan and other aspects of mobile phones. With a survey and follow up interviews they looked at the many factettes of mobile phone usage and answered questions like "What do people do with their old phones?". With the collected data, they tried to find "Opportunities for Sustainable Interaction Design for Mobile Phones" [5].

Since then the mobile phone market has changed. Important factors like the mobile phone service plan have since evolved and thus it would be interesting to see the difference 8 years make on the behaviour of mobile phone users. To make this comparison and to find new insights, this paper was designed as a follow up to the one published in 2008. The goal of the paper is to gather enough information from the collected data to be able to create implications and design ideas for a more sustainable mobile phone market and design.

A qualitative survey was conducted followed by interviews to find out how people use, acquire, value replace, and discard their mobile phones. This information was then analysed to find challenges and opportunities for sustainable HCI.

Results show interesting insights in how people interact with mobile phones and some implications and ideas are given from the data analysed. These findings may give ideas for further projects in the field and are suggestions on how things could be approached.

The thesis is built up in the following way: First the related work and research backroad is described to give the reader a good picture of the current situation of the topic. Then the methods used to conduct the survey and interviews is described. The survey and interview responses are shown and analysed in the next part. A discussion of the results follows this, showing implications and new ideas.

RELATED WORK AND RESEARCH BACKGROUND

SUSTAINABILITY IN HCI

Sustainable human computer interaction has been an interesting branch in the past years. Especially in such a rapid growing market like consumer electronics it is important to look at the potential effects such a production can have. With increasing reliance on the digital world, electronics become more abundant and have short lifecycles, thus they are prone to be unsustainable. That is why it is important to look at the subject from a design standpoint, both in hard- and software.

Looking at the pleasure cycle of a product and showing choreographed and built in obsolescence [6] really outlines some of the core problems with sustainability as Woolly did in 2003. There is a high pleasure in purchasing a product and customers must judge the products mostly before properly using them. This gives companies little incentive to design for long lasting products and thus it creates a problem for sustainability. The paper suggests that the designs of these products must be changed drastically to, amongst other points, to change the pleasure cycle and with that the longevity of new technologies.

By the paper from Mankoff et al. [9] the topic of sustainable HCI was brought up more and showed what the importance of it can be. It may even play a role in preventing climate change and is important for keeping a balanced environment in this age of digitalization. Blevis et al. [7] showed how that it is not enough to just fight the symptoms of the vast amount of electronics like providing a recycling service but that disposal is linked to the design of the product.

Those two papers show clearly that the design of a product ultimately determines its sustainability and that measures need to be taken to incorporate sustainability into the design process. This creates a shift in how one looks at the problem of sustainability but also offers new ways to approach the problem. Finally the paper of Blevis et al.[12] shows how sustainability can be integrated into HCI.

One reason sustainability fits well into HCI is also because there is not just a problem with hardware but also with the software. The frequent updates and need for more power to run the newest software fuel the need for new hardware and thus makes the hardware obsolete. Wullert et al. [29] has identified this as a problem early on and showed that software is a key aspect of creating a sustainable environment with persuasive computing systems.

The paper of Baumer et al. [8] takes this even further by pointing out that one may also have to ask the question if it is even worth it to design in the process of creating information technology. While not condemning or even discouraging new designs, one should see if the

novel design offer benefits over existing solutions. This brings a different way of thinking especially in the design process of electronics. This is hard to implement commercially but it may still have an impact on other projects that do not have money as their sole purpose.

In many papers addressing sustainable HCI there are several ideas and frameworks about future behaviour. These frameworks are often not scientifically tested after being proposed, creating an environment of untested ideas. This theory-practice gap was identified by a HCI paper [10]. In this example the attachment framework [11] was looked at, giving interesting insights of how one should use look at and use frameworks.

CONSUMER ELECTRONICS AND SUSTAINABILITY

Consumer electronics have a significant impact on the environment. They contain many substances that can be harmful if not recycled correctly. They also increase energy consumption and thus can negatively impact our surroundings or be wasteful. This poses a problem due to the extreme amounts of products bought every year. A lot of those products replace old devices that then need to be recycled.

Bates et Al. [13] shows that digital technologies used non-commercially are not sustainable. The paper suggests to take a more radical approach on the subject to solve this problem by finding a way to rely no longer on digital services. Additionally, the paper suggests that for a truly sustainable environment we need to create carbon neutral devices that people depend on for their lives.

Another interesting subject was pointed out by a paper [13], that sharing devices may not always be a good thing. It points out that by sharing, one may open a door for someone to become reliant on a product or just become accustomed to it. This would then increase demand for the product and thus contribute to more unsustainable behaviour.

The paper from Huang et al. [5] looked at the usage of mobile phones using a survey and interviews from the angle of sustainable HCI. It examined the disposable technology paradigm ("technology that comes with the expectation of a short usage lifetime, despite the potential for a longer functional lifetime" [5]) by conducting a survey and interviews, making a qualitative study. They asked the respondents questions about their usage, view and recycle behaviour of mobile phones to then make create ideas for further work in interaction design and sustainable HCI

It [5] identified some new design ideas for a more sustainable environment in this field from the data they had gathered. One example of an idea is to create phones that are more modular in a style and design aspect. Furthermore, the paper outlined the situation of mobile phones in 2008, showing what was valued in a phone and how aware people were on the topic of sustainability.

Some insight on how the effects of interactive technologies on sustainability were viewed by people was given in a paper by Hanks et al. [14], by doing a broad study with undergraduate students. They divided the students into four categories depending on their concern about sustainability and how much they like new products. By doing this, they showed a way to divide the target audience which is important according to the paper of the theory-practice gap [10]. It gave an insight on how the upcoming generation was handling mobile phones and how their thoughts and knowledge of a sustainable environment influenced their behaviour.

Another important aspect of sustainability of mobile phones is transferability. It can extend the life cycle of a phone and reduces the need to buy new phones (although it may have other side effects as mentioned by [13]). To have greater insight on transferability, a study [15] was conducted with 35 phone interviews with people from Germany, Japan, US and Canada. It showed that there were differences in habits or thoughts towards transferability depending on the country. In Japan, the concern for security when giving away a used phone was much greater compared to the other countries. Participants from Germany on the other hand were much more open to a transfer of their phones. This means that if one were to design to increase transferability, there may not be a solution that fits everyone's needs.

Despite all this analysis one cannot be sure of the situation is still the same as when those studies were conducted. Trends can change quickly especially in such a quickly growing environment. In a study [17] it showed the changing replacement time of phones and identified the subsidies from contracts towards new phones to be a defining factor when it comes to replacing a mobile phone. It also showed that people in the US had the shortest cycles for phones. This gives a very interesting idea that maybe the decline of the famous two-year contract could mean that the replacement cycles of mobile phones could change. In the example in the paper the people in Finland who had no or few subsidies had the longest replacement cycles of around 6 years at that time.

Sustainability can also come from the producer's side, like in the example of Fairphone [27]. This different take on a mobile phone is laid out to be much more sustainable and puts a lot of emphasis on acquiring parts of the phone that are fair towards the producers and the environment. The Fairphone is designed to be modular so broken pieces can easily be replaced. They use Fairtrade gold and put emphasis on recyclable materials.

In a paper by Joshi et Al. [28] they showed that a concept like the Fairphone could make a significant difference. It raises awareness and could start a movement for a more sustainable environment. It shows up that by the support of a community, concepts like the Fairphone could change design ideas on a more extensive level to facilitate change.

RECYCLING AND WASTE

When talking about sustainability with consumer electronics, recycling must be a topic to discuss. The materials in electronics can be very harmful for the environment if not recycled correctly. Electronics are often shipped to third world countries [22] and left there to be

somehow salvaged with insufficient technology and resources to do so properly. Additionally, electronic devices still land in the trash or are kept at home instead of being recycled. This massive amount of disposal could be alleviated by encouraging people to reuse or remanufacture their electronics.

In a paper by Zheng et al. [18] the effect of primitive e-waste recycling was examined. The lead and cadmium from the e-waste pose a threat to the people living around the site. They found that *“Environmental pollution, especially lead pollution, has threatened the health of children living around e-waste recycling site.”* [18], showing just one of the bad sides of recycling electronics. This can affect the water of whole regions and thus cause great damage to a community.

Michelotti et al. [19] show that proper e-waste recycling can be a very difficult task and that a complex recycling system is needed to reduce disposal of metals in an effective way. This and the paper described before [18] show that shoving off the electronics to other countries is not a good solution. In poorer countries, they may not have the necessary resources to handle the recycling in a non-harming way, as shown by those two papers.

Recycling and waste is not a new topic emerging with e-waste. Many other products such as food cause huge amounts of waste and the e-waste research can learn from studies in other fields. In a paper about food waste [20] they have used a tool called BinCam that shares pictures of waste on the internet. They found that by raising awareness of people, they tend to reflect on what they have done and think about their situation. According to the paper it is helpful to aim efforts to increase recycling at self-reflection. This reflection then lead to people seeking to educate themselves about recycling, to then improve their behaviour for the future.

A way of encouraging people to recycle is in a more playful way, shown in [21], where people were encouraged to recycle with a game. This relies on a crowd to improve knowledge and work together to recycle the products appropriately. It also aims to bring up some sort of competition between people to correctly recycle. By doing this in a crowd based environment people only did about half the mistakes they did as individuals.

Zhang et Al. [16] furthermore demonstrates how the recycling behaviour of e-waste is in people of a similar age group as [14]. They have found that a lot of the participants in the study had had a positive response towards recycling of e-waste. These good intentions were stopped however, because there was not enough information and insufficient services for e-waste recycling. This shows again how complicated this matter is and that there are many points that need to be considered when tackling the problem of e- waste.

Ideally, people would rarely even come to the point of having to recycle or produce waste by keeping their electronics. In a paper from Odom et al. [11] they have identified a framework that outlines things that determine attachment to an object (engagement, histories, augmentation, and perceived durability). Through this, designers have some guidelines when aiming to produce a more sustainable product.

Another paper [23] expanded on this attachment framework by doing a personal inventory study with 17 households. They added earned functionality, perceived worth and sufficiency as additional classifiers for categorizing attachment. This brought up that the use of the object was also an important factor in attachment. By then changing the design principles accordingly and producing products that are more likely to cause attachment, they may also be less likely to be thrown out and cause waste.

Turner et al. [24]. examined the attachment to objects and explored the difference of attachment between digital and non-digital artefacts. They found that there is no significant difference between the two. Other factors still played a role like how close the object is to the body and if it was given as a gift. Through this it can be assumed that the findings concerning attachment to objects [11] [23], could also be applied to digital objects.

Finding ways to repurpose old equipment can also be a way to prevent the electronics from landing in the trash. This was examined by Paulos et al.[25], showing how the different kinds of ways to reuse as is, remake or remanufacture the products. This is yet an uncommon thing to do and the paper suggests that a community to share ideas and projects is needed to spread the idea of repurposing electronics. Depending on the level of repurposing, the skill level required varied greatly (for example remanufacturing took extensive knowledge in the field).

Reusing Electronics can also be a way to reduce the impact on the environment. Another paper [26] looks at what inspires people to buy used products. It found that nostalgia was an important factor and that the products were still functional. The paper suggests a social platform to share resources and knowledge and a recommendation system. In both papers mentioned one of the big hurdles is to motivate people for repurposing or reusing and to raise awareness of those topics.

SURVEY AND INTERVIEW METHOD

SURVEY

OVERVIEW

The survey was conducted for two reasons initially. The first was to gather information from the participants to have a better insight on their behaviour and thoughts about mobile phone usage. The second reason was to find participants with interesting and varied answers to then conduct a follow up interview. This would then allow to choose from a wide range of short answers and pick the ones that would be interesting to learn more about. It also allows to control the current countries, age groups and occupations from the participants to some extent to have a varied audience.

SURVEY DESIGN

The survey was first designed without a survey design tool to allow easy adjustments. All the desired answers were listed to then design the survey to get the responses that are needed. Then several design iterations of the survey were gone through by always checking and reworking it. As an additional input the original survey from the study made in 2008 [5] was used to ensure a that the new survey allows comparison with the results from the old one.

After there seemed to be an acceptable version of the survey it was converted into a survey tool. A few different tools were examined like Google Forms [30] or Surveyplanet [31] but ultimately the best fitting tool seemed to be Surveymonkey [32]. It offers a variety of different features to create questions according to one's needs and has an integrated way to easily share surveys over the internet. Additionally, it also has a rather good evaluation of the collected data to have an easy insight over what has just been collected and what is still needed.

After the survey was integrated in Surveymonkey, the it was tested and evaluated by HCI experts of the People and Computing Lab in the University of Zurich. Once the suggested changes were adapted, the survey was tested on 6 people from varying age groups under supervision that did not have HCI training. It was recorded where the participants struggled and they were also encouraged to make suggestions for changes or to point out where they had trouble.

The survey consists of 44 questions containing both open and close ended questions. It takes every user through a unique path, depending on how some key questions are answered. At the end of the survey the participants are asked if they are willing to take part in the interview and an option is left to leave personal data to allow contact.

There are four main parts of the survey. In the first the participants were asked about their personal information like their occupation and age. In the next part, they are asked about their current and previous phone, trying to see their behaviour with their phones and how they keep, acquire, and replace them. The third part consists of sustainability questions like how they recycle, if they use used phones or make repairs. The last part has hypothetical questions about concepts. It asks if they are interested in things like replaceable parts or other concepts for phones.

COLLECTING RESPONSES

Ideally the respondents would be from around the world in various age groups to have a good view of how these differences influence the answers. The goal for the number of respondents that completed the survey was set at around 80, more if there were not enough willing to conduct the interview.

One way of collecting the responses was via social media. People were asked to share the survey on their social media and to also motivate more people to do so. This allowed a good amount of responses to be collected however, they were mostly from the same demographics. With just this method the areas the survey is taken from and the age group of the participants would not have varied enough.

To get more controlled responses other means were used to collect them. Sites for exchanging survey responses for services, like filling out other surveys, were used to fill up some of the holes that were left. In the end 196 survey responses were collected of which 151 completed the survey fully.

INTERVIEWS

OVERVIEW

The interviews were conducted to get in depth qualitative data on the subject. Participants were asked about their behaviour with mobile phones, how they use them, recycle them and other topics relating to the previous questions asked. Depending on the answers they gave in the survey, the interview was adjusted and questions were asked if there were any signs of interesting behaviour.

PREPARATION

Each interview had a preparation phase where the survey response was closely studied and an individual interview plan was made to loosely lead the conversation. Even though there was a rough plan of questions the goal of the interview was to go along with what the participants was saying and inquire more when there were any interesting remarks. The plan was there to make sure important topics were mentioned and to not drift off too much from the topic.

METHOD

A lot of emphasis was put on the stories of the participants and they were encouraged to just explain. The goal was to not talk much as an interviewer and only give direction to the conversation with a few short sentences. There was a mostly relaxed atmosphere so the participants could speak most freely. In total, 12 interviews were made that lasted between 25 and 35 minutes. Ten of them were held over Skype and the other two were held via a phone conversation.

FINDINGS

SURVEY

PARTICIPANT INFORMATION

The participants had the following age groups as seen in **Figure 1**. Participants from older age groups were hard to find and 48% of the participants are between age 21 and 29. They were 45% male, 51% female and the rest did not specify their gender. The majority of the participants is from the United States of America (50%) while the rest were scattered around the world as shown in **Figure 2**. The occupations also varied greatly with the participants, however students were the most common followed by Administrative Assistant and Engineer. Only 3.5% of the participants did not own a current mobile phone.

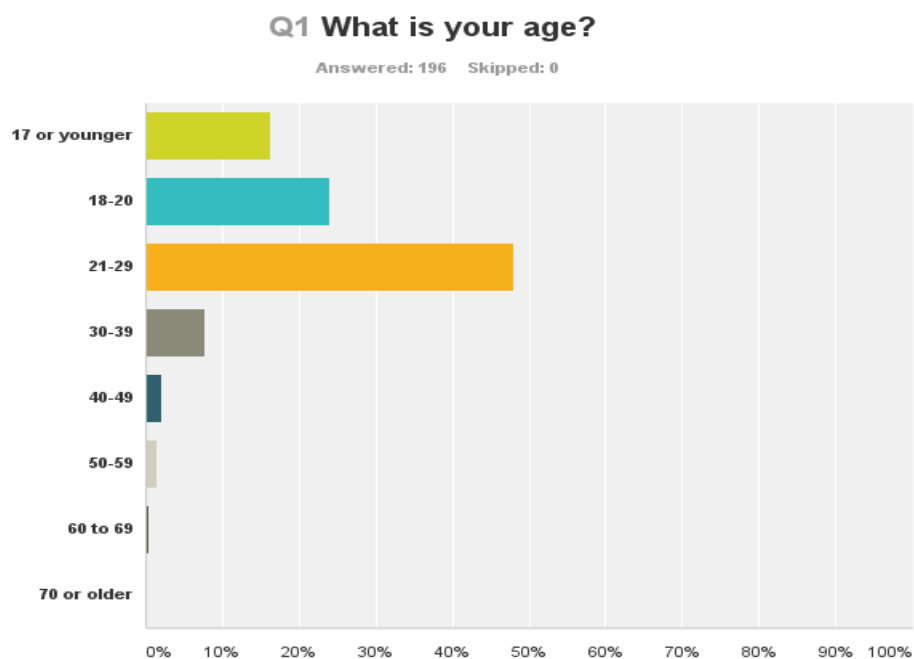


FIGURE 1

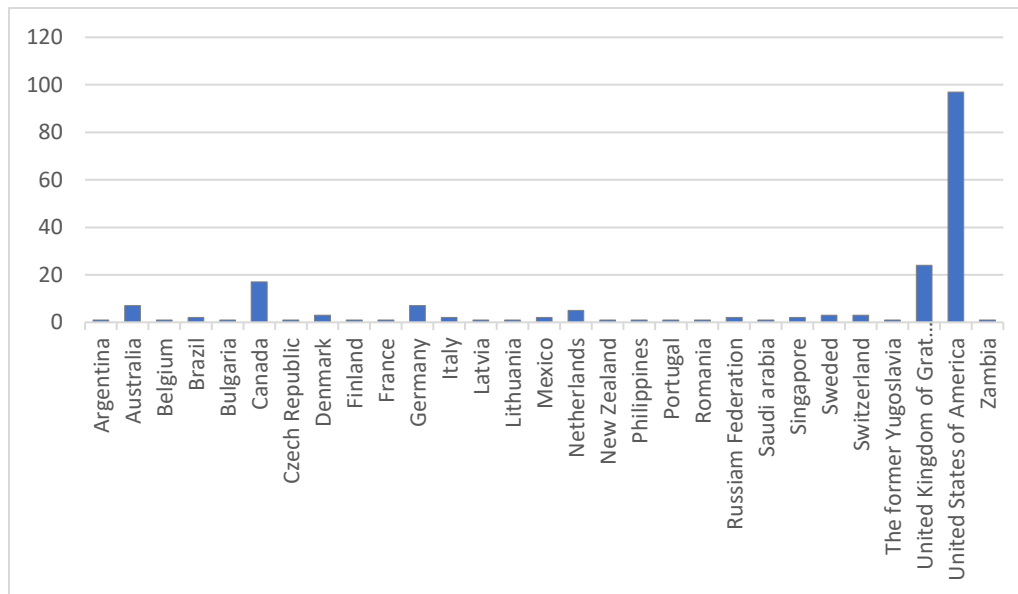


FIGURE 2

CURRENT MOBILE PHONE

From the participants 76% bought their latest mobile phone new of which 47% bought their phones together with a service plan. 14% received the phone as a gift, 5% bought it used and 1% got it from work. As a service 73% use a phone contract, 16% have prepaid, 3% no service and the rest a pay-as-you-go service.

When asked about the reason for selecting the current phone over other options, Brand loyalty was an important aspect. From the participants, 29% mentioned that the brand was one of a few or the only factor for choosing the current phone. Out of these 19%, 8% chose their phone because it was an iPhone. Android was only mentioned in 3% but other brands that run android such as Samsung were a prime factor. Features were also a top reason for choosing the phone since 24% mentioned that functionality was important to them in their new phone. The rest of the topics were mixed and small in number like quality, colour or size.

PREVIOUS MOBILE PHONES

Most of the participants also had a phone prior to their current one, with only 10% having no phone before. They used their previous mobile phones on average for 2.3 years, as a median 2 years, minimum 2 weeks and maximum 8 years. On average, they owned a mobile phone for 9 years of their lifetime. In these years, they had owned around 5 phones on average of which 3.5 on average were still in their possession.

When asked in a multiple-choice question why they replaced their old mobile phone, 40% mentioned functionality, 48% it being damaged or broken, 15% because the contract ran out, and 2% because their phone was stolen or lost.

After the participants stopped using the phones, 60% said they still have the phone, 13% gave it away, 6% sold it, 8% traded it in through a service provider, 6% discarded it and 4% recycled it.

When the participants were asked about uses for the phones they kept, only 20% still had a use for them. The most widespread use for keeping old phones was to have a backup in case the new phone would break but this may not necessarily be considered as using an old phone. Other reasons for keeping old phones were to listen to music, use it as an alarm, testing code, for sport trackers, watch porn in the shower, for holidays, or to use a sleep tracking app.

For reasons to keep phones that were no longer used the participants listed various reasons. One important point that often occurred was that they either did not know at all what to do with the phones or did not know where and how they could recycle it. Another reason was to keep the phone out of nostalgia or because there were files, mostly photos, on it that they wanted to keep. A different common answer was that they just did not come around to recycling it or did not find the time to do so. The last common reason for keeping the unused phones was because they were scared about the data on the phone if they were to give it away.

From all the participants 33% acquired a used mobile phone in the last 5 years. From this group of people, they mostly received the phone from people they knew (53%), while some were bought online (27%), bought from people they knew (4%) or bought from a second-hand store (2%).

The main reason for getting it used was the price of the phone. Over half of the participants who acquired a used mobile phone did so because it was cheaper. Another reason that was often mentioned was that they got their first phone from their parents that they had used before. It was also mentioned that they did not want to waste money and that they thus got a phone from a relative.

REPAIR AND RECYCLING

From all the participants 30% had a battery replaced in their phone in the last 5 years. From those replacements, 63% were due to the battery not lasting long enough. The rest was replaced because the battery was completely broken or there was a recall. 60% of the replacements were done by the participants themselves, while 19% replaced it in a shop and 13% had the phone sent in.

From all the participants, 40% had their phone repaired besides battery replacement. The main reason was to repair the screen with 58%, followed by the camera with 7% and the physical buttons with 3%. The rest were single different cases. 59% of these repairs were paid by the participants themselves while 35% was paid by the warranty or insurance.

Most of the people who got their phone repaired, did so in a local repair shop. This was usually found by searing in the internet. Many stated that they were pleasantly surprised how fast the screen repairs were. Some sent their phone in to their provider or phone brand

company to get it repaired. Very few tried to repair the phones themselves. Some were successful but there are also comments about how the phone was completely broken after attempting to replace the screen. This seems to be a hard task for someone who is not trained to do so and may leave the phone damaged or broken.

Only 7% sold a phone in the last 5 years. Of those, 40% were sold online, 20%% were sold directly to a person they knew and the rest was either sold back to the store or to a second-hand store. Most of the participants sold their phone to get money to acquire a new phone. Few sold it just to get money for other things and one sold it because he bought a temporary phone since his main phone was in repair.

In the last 5 years, 20% donated a phone or gave it to a trade in program. Very few did so because they got money for it. Environmental reasons were a big point why the phone was recycled. It was mentioned often how horrible it is for the environment to throw it in a landfill. Many felt bad for keeping it or throwing it in the normal garbage. Some were giving away their phone because it was still working well and they wanted someone else to use it. Some had a more practical approach and just wanted to get rid of the phone because it was no longer needed.

Mostly, the phones were recycled or traded in through local stores. The most common was to drop it into a recycling bin, where there was the smallest effort to be made, this was also mentioned as a reason why they even bothered to recycle in the first place. Some handed their phones back to their carriers or brought it to mobile phone shops. A few put sent in their phones via mail to either their carrier or to a recycling program.

Only 10% of the participants discarded a phone directly into the trash in the past 5 years. When stating a reason why the phone was discarded, 75% stated that it was because the phone was broken, damaged or too old. From the comments, it seems that the participants don't really know that the parts of the phone could be of use when recycled and only think it can be given away when it still works. Some just outright said that they were too lazy to recycle it or that they did not know what else to do with it.

REUSE AND MODULARITY

When asked about renting a mobile phone by paying a monthly fee, 30% of the participants said that they would be willing to do so if they were to get an unused device. This number changes drastically when asked the same question about a used device, where only 14% would be willing to take such a service.

About the concept of replaceable parts most participants were quite positive, 90% of them would be interested in phones where broken parts could be replaced with identical new ones. Only 56% would be willing to pay more for a phone with such functions. Nearly as many would be interested in a phone that has a modular design, where parts of the phone could be replaced with upgrades, like a better camera. 88% of them would be interested in such a phone and 72% would be willing to pay more to have these features. This is considerably more compared to the 56% who would be willing to pay more for a phone with replaceable parts.

INTERVIEWS

PARTICIPANTS

The participants were chosen from around the world while 4 are from the USA as seen in the chart for an overview of the interviewees. The country listed with the participant is where they currently live. Many of them have grown up in other countries or lived in different locations in their lives, meaning that English was not always their first language.

Number	Country	Sex	Occupation	Age
P1	Switzerland	Female	Retail	24
P2	Mexico	Male	Insurance company	29
P3	USA	Female	Administrative assistant	25
P4	Singapore	Male	Student	18
P5	USA	Male	Barista	27
P6	Australia	Female	Student	18
P7	USA	Male	Accountant	44
P8	USA	Female	Unemployed	43
P9	Canada	Female	Call Centre	26
P10	Romania	Male	Student	22
P11	Germany	Male	Baker	29
P12	Netherlands	Female	Student	21

They were originally planned to be selected from all the participants from the survey, however there were problems with getting the planned money from the university to compensate the people for interviews. Because of that, the interviewees could not be

selected from the survey participants freely. Instead, volunteers were searched that would conduct an interview for free. These were mostly friends of friends or some of the contacted people from the survey.

This is obviously not an ideal process and needs to be taken into consideration when evaluating the results. However, despite this problem a varied group of interviewees was found that had different behaviour in using mobile phones. All the interviewees were asked to take the survey before the interview was conducted.

The interviewees all consented that they could be anonymously quoted for this paper and that some of their basic info could be published (like age or occupation). All comments that did not have anything to do with the subject are to be left out.

ANALYSIS TECHNIQUE

After the interviews were conducted, they needed to be transcribed. For this, a homemade transcribing pedal was built to make it more manageable. The interviews were then transcribed into a word processing software. Not all of the conversation was transcribed, only parts that seemed to have something to do with the subject and obviously not the personal remarks the participants told me to leave out.

After the interviews were transcribed, they had to be analysed. To have a good overview of the different topics and to manage the vast amounts of quotes, an affinity diagram was made. Each quote was printed out with the participant number and reference number to easily find it again. For the diagram, comments that had similar meaning were grouped together to create different topics. These were split up into high and low level topics for a good organization. In **Figure 3**, a small part of the affinity diagram can be seen while in the process of creating it.

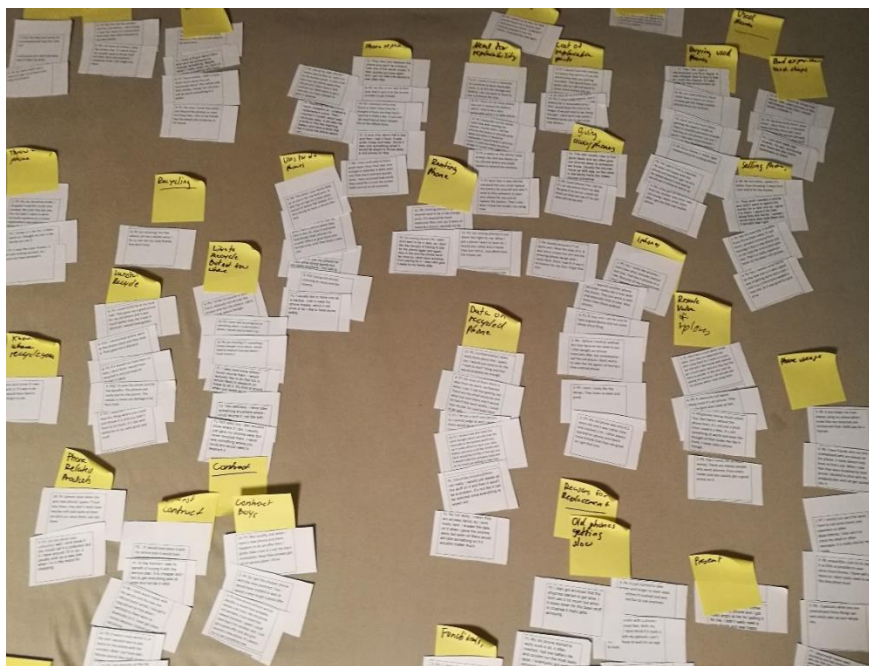


Figure 3

In the following section, the results of the interviews are analysed and followed up by suggestions for opportunities or design implications.

THE VALUE OF OLD AND FORGOTTEN PHONES

Storing phones seems to be a main solution when handling phones that are no longer in use. In the survey, 60% of the participants stored their previous phone and from all the phones owned, 70% were still in their possession.

Some participants still had uses for their old phones. They ranged from using specific apps such as one that monitors one's sleep to using it as a device to listen to music. Four of the interviewees had some use for their old phones but only two of them used the old phone regularly.

"The other [Phone] I use nearly daily as an alarm for my bedroom.... It also has an app on it that plays noises to fall asleep. It's very handy to have a device like that" (P8)

"When they [friends] come over he [a friend] gives them a phone while they stay in the US... If someone else breaks their phones he usually offers to give them one temporarily until they have a new one" (P5)

"Listening to music and the camera." (P10)

"I used to use my iPhone for music while doing sports but not really anymore. The rest is not used at all." (P1)

This is somewhat similar to the findings from the survey. While some participants did use their old phones, it was often not much or just for special occasions. When asked about why they stored phones that they no longer use, the interviewees were mostly caught off guard and did not really know what to say. Most didn't think about it much yet like the following participant:

"Yea probably, I didn't really think about that. Eventually there'll be a whole pile. Who knows, maybe the old ones will be worth something one day!" (P7)

These old devices were usually stored in places where they would not often come across. Nearly all interviewees had not really thought about a use for their old phones or what they would eventually do with them. Some stated that they lacked motivation, which seemed to be a point even with the ones that this not specifically state this.

"I kind of forgot about em... Maybe when I clean my room I'll do something about it." (P1)

"The people I know either just discard the phones or most keep them... One of my friends has a pile of phones at his house... Most of them are just too lazy to do anything." (P5)

Even the participants that stated that they were concerned about the environment and were eagerly recycling other products stated that they had trouble with recycling mobile phones.

"I still have all of them, even the broken one. It's weird since I am usually quick to throw stuff out that I don't use... I somehow think I still might use them." (P9)

This is interesting as it appears that the problem with e-waste can be different to mobile phones in particular. It seems that the phones are small enough to not take up too much space for a person to consider it a disturbance. Like this, the phones can at times be completely forgotten while causing little to no trouble for the owner.

Despite not using the phones in most cases, most of them still attributed some value to the phones they no longer used. Just like in the survey results, the main reason was to keep it as a backup in case their current phone broke:

"I like to have one as a backup. Just in case my phone breaks, which it did once so I like to have some safety." (P1)

"I don't really have a reason to get rid of those since they all still work... Besides, they are so small, so I don't mind storing." (P4)

"Whenever I get a new phone I think that I'll use my old phone for something. As a backup, whatever... I never end up using the old phones... I only sold one... I mean keeping one as a backup is kind of rational and smart I think... just the really old ones I would need to get rid of." (P11)

Even participants that did not have any use for the phones at all and did not plan to use them in the future were not able to get rid of them. Reasons for that were that they valued them, did not think of them, it was too much work to dispose them or because they did not know what to do with the phones. A common thought was that they could somehow still be used. Since the phones take up little space and are easy to store, it seems to be a low enough price to pay to be able to keep this little value.

Thinking only about the old device just as it is replaced seems to be common amongst the interviewees. Their main decision of what to do with an old phone seems to be at the point where it is replaced with a new one or shortly after that. This means that once the phone gets past this point, it seems that it is much more likely to be kept and that nothing will be done about it. Since at this point, the interviewees still attributed high value for the phone as a backup or because it still has functionality (and memories of its functionality due to recent use), they were very likely to keep the phone. Once this value decreased over time and the reason for backup diminished because another phone was acquired, the thoughts all turned to the new phone and the most previous one, while the ones before remained mostly forgotten. So, it seems that for the interviewees, once the attributes value of a phone was low enough for it to be given away, it was mostly forgotten and not worth the effort due to little personal consequences.

DISPOSING PHONES AND THE LACK OF KNOWLEDGE FOR RECYCLING

As seen from the survey, there are many participants that were confused about recycling mobile phones or that did not have enough information about it. Some just tossed it in the trash and many, as seen from the comments above, kept their phones. The interviewees showed similar behaviour, while three did recycle their device properly, the rest did not do so in the last 5 years. Just like in the survey results, the participants that had thrown away a phone thought that they had no other option:

"it was like super broken, it fell and nothing worked. I could not have donated it." (P3)

"I threw it in the bin, it didn't work so I thought no one in the family can use it." (P2)

P3 assumed that there was no other place to get rid of an old phone than to donate it to a charity. When asked about what he thought about recycling she said *"I did not even think about that, I don't think we have that here"*. P2 was in an environment where it was usual to give old phones to family members and friends. Thus, for him a phone that was broken could not be given away and he also did not consider recycling.

The most common way to recycle was through a shop or mall that was close by that offered some sort of program as seen by the survey results. They were mostly just stores where they saw the program accidentally and did not do any research for it. They also were locations that they anyway went to, so they did not have to go out of their way to recycle their phone:

"I recycled it in a shop, it had this thing where you could just toss it [the phone] in and you didn't have to do too much. It's like with batteries, very quick... If it would not have been so easy I don't think I would have recycled it." (P3)

The comment shows that convenience seems to play an important role in recycling. P3 was the participant that threw away the phone that did not work but is willing to recycle if it is functional. The following participant seemed to be motivated by the monetary discount he got by bringing in his mobile phone:

"I used ECOATM at my local mall. They gave me a good price for my old phone... it was much better than the trade in discount I would have gotten." (P5)

Only one interviewee made extra effort to recycle and researched online how to do so:

"I researched online, went to the phone store and they took it. They gave me a discount ... To save the planet and for the benefits.... The phones are bad for the planet.... The metals in there can damage a lot." (P10)

The rest of the interviewees mostly had a very positive attitude towards recycling and seemed to sincerely want to do so. Even if they did not recycle any of their phones, they were very open to it:

"Yea definitely [wanting to recycle], I just never saw something where I could recycle it, not like with batteries that you find everywhere.... I would like to do that but I would need to research on how to do it. It's kind of stupid when you want to do something good but you have to put in that much work... I try to do my best and recycle stuff and live a life that doesn't have a big impact for the environment. It's kind of weird that I don't do it at all for mobile phones." (P1)

"I have no clue how I could recycle phones. I think I might recycle if it would be easier, like with PET bottles, I just get rid of those while getting groceries." (P12)

All the participants that did not yet recycle had one thing in common, they did not know where or how to recycle mobile phones:

"That's something I haven't thought much about. I would need to research how and where I could recycle." (P8)

"I usually am eager to recycle things, I'm just not sure with mobile phones... I wouldn't know where to recycle them." (P11)

"We often bring electronics back to the shop to be recycled or we give them away.... I don't know if you can do the same with phones... We try to reduce the damage we inflict on the environment as much as possible." (P7)

One participant was thinking like the ones that threw away a phone, that the phone could only be given away when it is still fully functional:

"I never saw any program where I could donate a phone. I would need to look it up.... I'd like to give them away, obviously not the broken one but the others. I don't really know where though." (P9)

As seen from the survey results and the comments, there seems to be a big lack of knowledge in how to recycle mobile phones. The participants were very positive towards recycling and seemed to want to do so. They compared mobile phones to other products such as PET bottles where they were familiar with the recycling program and did so regularly. With mobile phones, they did not know where to bring them and were not aware of any recycling or donation program in their area. This could mean that there are either not enough programs or that the awareness for such program is simply too low.

DECLINE OF CONTRACT POPULARITY

As the survey has already shown, contracts are still an essential part of purchasing a phone and were often the reason why participants decided to purchase a new one. Some of the

interviewees also reflect this to some extent. For both P4 and P12 it seems that they would not have bought a new phone if it would not have been for the subsidies they received:

"I got the cheaper phone with the new contract. Else I would have needed to wait at least a year to get a good offer... No I would have probably waited a bit more [to get a new mobile phone without a contract]. My old phone still worked, it just wasn't new anymore. I guess I could have kept it for another year. I got a good offer and I just wanted a new phone. It's always fun to get something new." (P4)

"I don't think I would have gotten my last phone if it wouldn't have been for the contract renewal... It was cheap and my old phone was getting slow... I didn't know if my phone would last another year." (P12)

This shows that contracts have played a role in the decision-making of getting a new phone with some of the interviewees. There seems to be a fear that the phone breaks while there is no offer available and phones get replaced early because of this. However, there seems to be a shift in how those service plans are laid out. Many of the interviewed have stated that the subsidies for renewing the service plan have diminished and are no longer available or profitable:

"Yea, recently all the big companies stopped offering those subsidies for phones when making a new service plan. It doesn't really give a benefit anymore to get it together [The phone and the contract]." (P7)

"It wasn't really worth it, in the end I would have to pay more for the phone with the contract.... Now I just have data flat rate and all that stuff. It gets cheaper when you don't get a phone with it." (P9)

"Right now, I see no benefit of buying it with the service plan. It is cheaper... I like to get everything paid at once and not be in debt.... If I would have taken it with my service plan it would have cost more and over a longer period of time." (P1)

The interviewees seemed to be less likely to use a phone contract to buy a new phone but only for their most recent phones. Before all but one interviewee used a contract and the subsidies with it. Many of the participants still liked the idea of the contract subsidies but they were no longer profitable or not available at all anymore:

"I always used to buy my phone with a contract but now the offers seem to be getting worse." (P11)

"It used to be the only way I could afford a new phone frequently. Now my carrier reduced the discounts." (P12)

The comments suggest that throughout the world there seems to be a decline in the subsidies for mobile phones when renewing a service plan. While nearly all the participants

purchased phones with contracts before, they now either find them no longer profitable or the subsidies simply don't exist anymore. This was only seen with the most frequent phones the participants got, so it seems to be a new and emerging trend.

BEHAVIOUR WITH USED PHONES

Five of the interviewees either gave away or received a used phone. Two interviewees that had a used phone that was not bought also lived in a community that strongly encouraged giving away phones to others:

"I don't care too much about getting the newest model so there is usually someone around that has an old phone I can use... I guess I was lucky because I always get into situations where I got a good deal.... They both needed a phone and didn't want to spend the money for a new one so I gave it [The old phones] to them... I gave it for free since they are family. I guess I could have sold them but it wouldn't feel right... Usually the phones move up with age, so the oldest in the family have the oldest phones somehow." (P2)

"Whenever I get a new phone I post on Facebook that I have an old one... My last one I gave to my Cousin, he gave his old one to his daughter." (P12)

Both seemed to have a good community, mostly family, where they could distribute old phones. This seems to be a satisfactory thing to do as they spoke very fondly of it. They also seemed to feel obliged to some extent to ask their family if they needed it before doing anything else with an old phone. It is also interesting that the phones seem to trigger a cascade of events. Often the one that is given the new phone then gives his old phone to someone else until there is no more possibilities for gain by exchanging phones. In one case the cascade seems to start with the younger and the older generations get the older phones.

While the surrounding community can play an important role in the behaviour with used phones, it is not the most prominent reason among the participants. Just like in the survey, money seemed to be the main factor to buy or sell a used phone:

"Since money is rather tight I looked online for a cheap phone." (P9)

"Yea, I needed some money for the new one so it was a good way of getting some extra cash... I sold it to a friend who needed a new one. It was good for both of us." (P6)

Only one interviewee also considered the environment when buying a used phone:

"Yea, I did, I got a refurbished one from Apple. It was cheaper than buying it new so I took the chance... It's also better for the environment so it's a win-win." (P5)

Interestingly, even the participants that were especially eager to recycle or very positive towards sustainability were still not considering the environmental benefits of a used phone except one. It seems that there is not such a close association between used phones and environmental benefits compared to recycling for example.

Overall the participants were very positive towards selling a phone or buying a used one. This had to be coupled with some sort of financial incentive for them to even consider a used phone. Only one interviewee was negative towards the thought of having a used phone in general:

"Hmm I don't know.... I don't think so, it wouldn't really feel like mine and I don't know what the person did with it before... all that eBay stuff is really annoying, I got scammed... I wouldn't want to risk that with a phone where I spend loads of money." (P3)

Just like P3, three other interviewees also had similar thought about platforms that sell used mobile phones. They differed however that they were still positive towards used phones and even mentioned that they would think about getting one if there would be a better way to purchase them:

"I just don't like Riccardo [Swiss eBay-like platform] ... You're never sure what you'll get." (P1)

"I once bought a used phone but it looked worse than on the pictures... so I sent it back." (P12)

"If I would have a local store that sells used phones I might consider it." (P11)

This might suggest that there is room for improvement in the distribution and image of the secondary mobile phone market. With just one bad experience people may be discouraged to buy used again. This may also give opportunities for new ideas since there seems to be a demand for used mobile phones that come from a professional vendor.

From other papers like [15] one can see that data security can hinder transferability. From the interviewees, most were very unconcerned about data security when giving away their phones and are trusting in the phone's capability to erase all data:

"I would just delete all the stuff on it and then it wouldn't be a problem.... It's not like it can be restored once everything is wiped out." (P1)

"I didn't really think about that. I guess not. I would just to do the "reset to start" thing." (P9)

Only P7 had concerns about data security because he also used his phone for his job. If data from his office would be given to others it could have negative consequences for him, so he is not likely to even take a small risk of giving away a phone:

"I'm not a tech savvy person so I cannot judge as well. I guess there would be ways to irreversibly delete the data but I trust neither myself nor the phone service people to do that.... I know a few who have the same thoughts about security as me... Especially in the business world you can't really afford to have your data leaked. Personal information like emails with clients would be terrible if that got out. It would make the company look bad." (P7)

With 44 years, he is the oldest of the interviewees and seemed to have a high amount of responsibility in his job compared to other participants. This obviously may just be a coincidence but it would be interesting to know if the concern about data security tends to rise with age and job level.

Overall it is great to see that the interviewees seemed to be very positive towards used phones, both in selling and purchasing. This means that there is potential demand for used phones and if there is enough monetary incentive, people may also be willing to sell their old phones. However, what seems to hold some back are the means how to sell phones. Some stated that they did not trust online platforms where used products are distributed and that they would prefer a local shop. This may leave opportunities open for local second hand shops where people can inspect the phones before they purchase them.

HARDWARE MADE OBSOLETE BY SOFTWARE

The interviewees had several reasons for getting a new phone, like functionality, service plan or defects on the old phone. One reason stood out above the rest and seemed to affect 8 out of the 12 interviewees, that their old phone became too slow. Many have mentioned that besides other reasons that this one was a defining factor to get a new phone:

"The old phone was getting slow and the new one offered some features I wanted." (P7)

Many even had bigger problems such as crashing apps or overheating. This drastically reduced their enjoyment with the device and eventually lead to the replacement of the phone:

"My old phone started to really suck a lot, it often crashed, had low battery life, and couldn't run the most basic apps. I eventually got really annoyed and bought a new one." (P1)

"It got too slow and the contract on my service plan was at that point where I could get a new phone for less money.... It just started to take longer to open apps, sometimes it crashed and was not fun to use anymore.... Especially with a phone I need it to react fast. With my computer, I don't mind if it loads a bit but with my phone I can't stand it." (P6)

"I don't use it much but when it slows down for the basic functions or crashes it really gets frustrating." (P2)

These devices all seemed to still be functional but were not able to run the software on it in a manner that was acceptable for the users. It is interesting that they have a different

tolerance levels for different electronic devices. Besides the basic things getting too slow, some software simply no longer worked at all:

"I couldn't update to the newest software update anymore. Some apps didn't work and it overheated a lot." (P3)

These comments point out what seems to be an important problem with mobile phone sustainability, that the new software makes the phones obsolete. As new updates are added and new apps are to be run, the phone gets slower, eventually reaching the point where it is no longer enjoyable for the user to handle. As seen from the survey and interviews, this seems to be a prominent reason to replace one's phone. At this point, the hardware is often still fully functional but it can no longer cope with the newer software.

DESIGN AND VALUE OF IPHONES

Design seemed to play little role in choosing a new phone and mostly just features were mentioned or flaws of the old phone. Two participants did however mention the design and it was both in connection to an iPhone.:

"I really like the design. They look so sleek and nice. If I buy one I can be sure to have a good device and not some cheap thing." (P5)

"Mostly because it's an iPhone and I liked the colour of it. It was more unique but still had the amazing iPhone design with I really liked. Once I saw it, it was a no brainer for me that I'd get that one.... I wanted another iPhone because I fell in love with the brand. They work so well... look so cool. Way better than those android phones." (P9)

This was also reflected in the survey results. The iPhone had much higher brand loyalty compared to others and the design was often praised. Another interesting thing that came up with iPhone is that the participants felt that it was a much better investment because they were keeping better value over time compared to other phones:

"They [iPhones] have a much better resale value. Sure, it's expensive but after using it for 2 years or so you can still sell it.... My friends with android get a much worse deal... I end up paying less because I can actually sell my phones when I stop using them." (P5)

"I sold my iPhone and still got a lot of money for it, it nearly made me change my mind about getting an android." (P11)

This however, does not mean that they will sell the phones but it does seem to bring additional value to the device:

"Yea, I feel better about the phone then, it's not just a brick once I used it a little, it's still worth something... even the thought of that makes me like it more.... I never sold a phone though." (P9)

It seems from the comments that different phone brands have different behaviour of resale value over time. This may be interesting to look at when wanting to create a better secondary market. If one could make more phones more valuable over time it may be encouraging to sell used phones after getting a new one.

DISCUSSION

Through then analysis of the survey and interviews, several opportunities and challenges could be identified concerning mobile phones and sustainability.

Challenges:

- Keeping their old mobile phones because the phone may still be used one day
- Lacking knowledge of recycling/donation programs and little motivation to research about it
- Bad experience with ways to purchase or sell used phones
- Phone replacement due to slow phones cause by updates or new software.

Opportunities:

- Demand for used phones that have a quality check
- Very positive attitude towards recycling phones
- Decline of phone subsidies from providers around the world
- Still value in old phones

COMPARISON TO PAPER FROM 2008

Since the data that was gathered here had a similar topic to the paper from Huang et Al. [5] from 2008, it may be interesting to have a quick recap on what has stayed the same and what has changed in those years.

What stayed the same:

- People often still keep their old mobile phones at home
- The ones that recycle only do so if it takes little effort
- Participants struggle with getting information about recycling and go out of their way to do so
- People gave value to their old phones even though they barely ever used them
- Functionality is still important in a new phone

What changed:

- Contracts with service providers became less a less important factor when buying a new phone
- There were no cases where a participant was forced to change the phone because of the number or provider
- Participants were more eager to get used phones if it benefited them

- Design was very rarely mentioned as a role to purchase and was replaced by brand loyalty (which to some extent is also design)
- Functionality (or the phone not getting too slow/crash) has become one of the main reasons why people replace old phones

In the following part, the before mentioned challenges and opportunities are further analysed. With that, new implications and design ideas are formed.

KEEPING UNUSED PHONES

To address the problem of keeping unused phones, there are two directions to tackle it. The options are to convince people to find use for their old devices or to encourage them to give away their phone to be recycled or reused. Either way, it seems to be important to encourage this at the point in time when the phone is replaced. There, the interviewees had biggest attributed value for it and it decreased over time, making it the best moment to use the device for another purpose. Since the participants were likely to forget about the phone after replacement, it is also crucial to focus at this point.

When trying to encourage people to keep their phones, one could utilize that sense of worth that the phone still has and try to enhance it. One way would be to create a better online community that show people what can be done with the old device as suggested by [25]. This however may be challenging to reach the target audience and it takes effort which with the lacking motivation of the participants, may be hard to generate.

Another approach would be to design phones in mind of ubiquitous computing. Instead of just having the useless phones at home, one could utilize their strong computing power to run other devices that are less complex than a mobile phone. Through this, the computing power of even an older phone could be enough to run another device. This is probably not quite plausible at the moment but with the rise of electronic devices in our lives it may eventually be a possible approach. Mobile phones and other ubiquitous electronic devices would need to be designed in a more standardized and modular way in order for this to work.

An interesting part about this is that it may be very profitable for phone companies. Often do those companies produce other products (for example Samsung has a whole range of electronics). By letting customers use their old Samsung phones to run other devices, they gain a way to reach different markets they may not so easily have access to. Like this a whole network of devices could be built up that would be very profitable for the firm producing them. However, on the other hand one must also see that this may not be an ideal solution and may also lead to more e-waste.

A different approach would be a design idea to remind people of unused phones. One could work together with firms that have devices registered on an account like the Google account. When buying an android phone, one must log in with a google account and from

this point on the device is registered in the account. It can then be tracked for activity and see when it was used the last time. One could implement a program that sends an alert to the user of that phone after not having used the phone for a certain amount of time. If this is reached, the program could send a message to the account informing the user that there is an unused device that is registered and information about alternatives like recycling could be given. This may be interesting for firms as it would boost their reputation an own program could be started that profits the firms.

To make used phones more profitable for firms to collect, one could implement low resource apps that run on many generations of phones to be commercially used. Ideas for those apps could be for audio guides for tourist attractions or a security camera app. Like this, the phones could still be used and they would replace another electronic device, reducing e-waste even more.

RECYCLING, POSITIVITY TOWARDS RECYCLING, AND KEEPING OLD PHONES

When looking at the recycling of phones, the main issues seems to be the awareness and abundance of phone recycling/donation programs. All the interviewees that did not recycle did not know where or how to do so. They were very positive towards recycling and eagerly recycled other products. In general, they showed very positive responses to being able to give your phone away and were aware of their negative impact on the environment. However, they so far were only willing to put very little effort into recycling a device. This means that any solution proposed for this problem either needs to raise the willingness for taking action or offer an alternative that only takes very little effort.

One aspect that may cause this is that there are simply not enough programs to recycle or donate mobile phones. If the programs don't exist, then the people also can't be aware of them. This would be a more complex problem to solve since the infrastructure would need to be built up. At the moment, I do not have the data to assess this on a worldwide scale and thus cannot conclude if this is an actual problem or not. Taking the data from the survey and interviews however, it appears that the people who wanted to recycle were also able to do so and no one mentioned a lack of service. Because of this, it seems that increasing the abundance of phone recycling/donation services should not be the main target.

The other option then would be to increase the awareness for recycling and donation programs to utilize the positivity the participants had towards recycling. From the interview and the survey, it seemed that many lacked any information about this. Thus, some information would need to be delivered to the user, preferably at the time of purchasing a new phone. Projects such as BinCam[20] showed that raising awareness may help people to re-evaluate their view on recycling.

One design idea to give information to the user is through the phone itself by reacting to cues that often mean that a new phone is acquired. One such trigger that is quite abundant in phones is the transfer of data. Often mobile phones have a function to transfer data (such a contacts or pictures) to a new phone. Except in some special cases this likely means that a new phone was acquired. Since this process takes time, the loading screen could be used to give information to the user about what they could do with their old phone.

On this loading screen information like the current price of the phone on online platforms, the closest recycling station and a donation program could be displayed to inform the user how he could benefit from giving away the old phone (an example on **Figure 4**). Like this, the user gets the information when the phone still has higher resale value und is also informed about recycling and donation for phones that one may not be able to (or want to) sell. This would then also apply for older phones that they still own without using. Maybe the positivity the interviewees towards recycling would be enough to then recycle the phones with the newly gained information.

This would not only help with the awareness for recycling and donation programs, but also for selling used phones. People may be less likely to keep their phone when seeing the potential money that they could make. Like this, the urge to sell and get money may be able to compete against wanting to keep it as a backup.

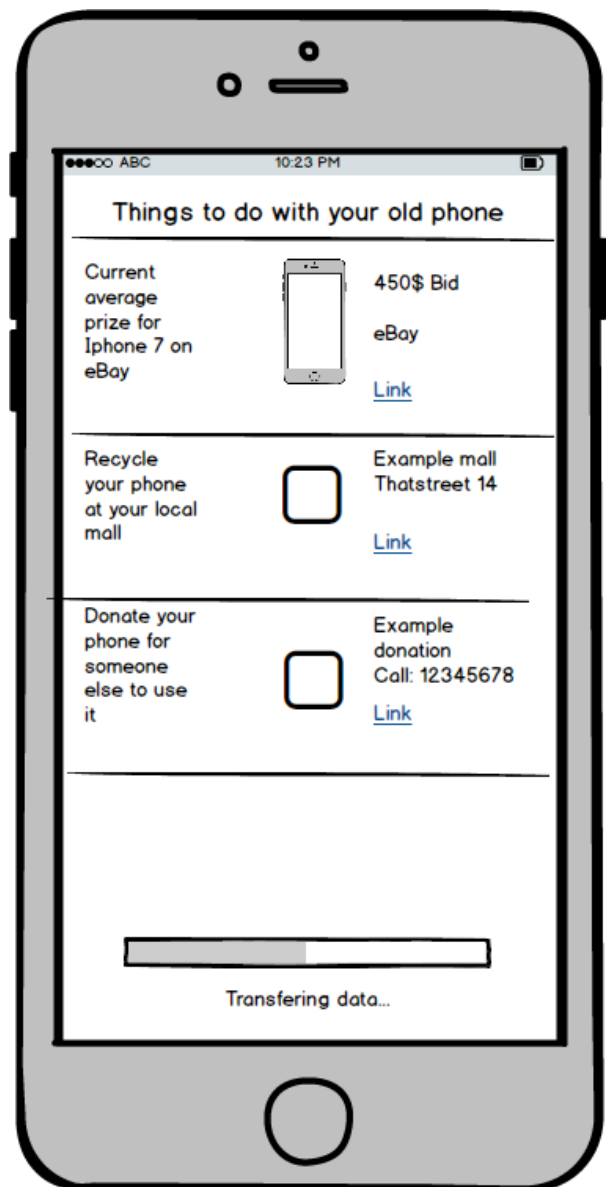


FIGURE 4

This information could also be triggered by other events that signal a change of phone like a new device registration on a Google or Apple account and an email with this information could be sent to the user. All this would also be interesting for firms that facilitate selling used objects because they could advertise and maybe make people enter the market that would not have otherwise. Due to this benefit, the firms might be interested in funding such a service.

REDUCTION OF PHONE SUBSIDIES AND ITS OPPORTUNITIES

From the survey and the interviews, it seems that the subsidies given by phone carriers to buy a new phone with a contract are on the decline. This is also supported by news articles [33]. According to the interviewees, the contracts were either no longer existing or had

prices where it was more profitable to just buy the phone at a local store. If this trend does indeed go on, it may have an important impact on the mobile phone market.

With subsidies gone, the price of a phone will be much higher and will seem even higher as it is all paid at once, and not partly over time through the contract. The price is also less hidden in the carrier costs and it becomes clear what you pay for a service plan and what for a phone. This may influence the behaviour of people buying new mobile phones.

One effect may be that people might take longer to replace their mobile phones. Before this shift, the contract renewal seemed to be an important cue to buy a new phone and may have seemed like a missed chance if not taken. Thus, people may be more likely to keep their phones for longer, as most participants stated that their phones still worked when they got it replaced. The increased up front price of the phones could additionally enhance this effect. A study suggests that Americans are already keeping their phones for longer than they used to [34]. That does not mean that it is because of reduced subsidies but it could be one of the reasons for this trend.

Whether the life cycle would go up or not, it would be likely that without subsidies the demand for high-end phones would decrease and the demand for midrange/cheap phones would increase. This might at first glance not seem too good for sustainability as there is less money to spend on more sustainable resources. If this change however would really occur, it would be the ideal time for new ideas to emerge and manifest into the phone market. Products like Fairphone could advertise that their phones last longer due to the reparability and are thus worth the money. Brand loyalty would take a big hit if the expensive brands would not offer cheap alternatives and thus leave a big chance for new and upcoming ideas.

Because of this, now might be the perfect time for a sustainable idea to emerge in the mobile phone market. If a product like Fairphone could also reduce the phone from getting slow from new software, there might find high demand for a phone that costs less over a longer period of time if people start to demand phones that last longer than two years.

REDUCING REPLACEMENT DUE TO SLOW PHONES

The interviews have shown that slow mobile phones are a prime reason for replacement. Especially if contracts become a lesser reason to purchase new phones, those secondary reasons become more important. Thus, it is crucial to tackle this to be more sustainable with mobile phones.

One design idea to reduce unneeded animations and actions from the OS by making it easy for the user to adjust and informing the user how to make their devices faster by using the operating system. Most android phones have a different version of the OS depending on their brand, with different overlays and designs. Some of them already offer an option to reduce animations in order to make the phone faster. This is usually hidden somewhere in the settings and thus hard to access for the average user.

Ideas like Fairphone could focus on making this aspect easily accessible for the user and include it in the starting tutorial or manual. They could reduce the animations and other

non-essential functions to a minimum to lessen the strain on the phone from the OS. Like this, the users may become more aware that the software may slow down the phone and would be less likely to get a new phone.

Additionally, the phone could monitor the amounts of crashes of programs and the loading times with by sampling. This data could then be used to give cues and information to the user. When the loading times get gradually slower, the phone may suggest to restart. When the loading times exceed a certain limit, the phone may suggest that the phone should be reset completely or that files should be deleted. To that it could monitor which applications cause most crashes inform the user and maybe suggest to change to update version where there were less problems.

While some phones can do certain elements of this idea, it is often not very easy for the user to find. A system like this may be a good starting point for a phone that would advertise on longevity and reparability.

BAD EXPERIENCE WITH USED PHONE SELLERS

Some of the interviewees mentioned that they did not like the options for buying a used phone. They were scared of scammers or the phone was not in the condition it was supposed to be. Since a mobile phone is a very personal object, always being carried around close to the body (as shown by [24] that one tends to attach more to objects close to the body), it may be important that it is exactly how the buyer wants it to be.

Demand for used phones seems to be there in abundance according to the interviews and survey results. One condition for this demand was that the phones worked well and matched the buyer's expectations. For this to be met, either the online platforms selling used phones need to gain trust and reliance or there is need for local second-hand shops.

If there is really a shift away from mobile phone subsidies, demand for cheaper used phones may rise even more and second-hand shops could thrive in this environment. By offering a service to rent out phones to be used as a back-up in case of emergencies, users may be more keen in selling their old phones and thus creating a good market. Shops could benefit from giving an alternative to just keeping the phone by not having to pay too much for phones. They would also help with the customer's confidence as they could look at the phones personally and check how the phone works.

Obviously second-hand shops for mobile phones already exist and are nothing new but according to the interviews, most did not have access to such a shop. This may be a chance for new shops to pop up and make a change in the secondary mobile phone market while still having a profitable business. With some extra ideas like offering backups or fully wiping the data from an old phone, such businesses could be highly profitable and create a more sustainable mobile phone environment.

To further strengthen the secondary market, one could look at the iPhone and its resale value. It seems to keep a higher value for a longer time compared to other phones of a similar price. For one the trust in the brand surely had a big influence on this which would be

hard to mimic with a new concept. However, there may also be other factors such as the design and the performance over a long period of time that may influence its resale value that could be utilized by other brands.

Another way to approach the problem with mistrust in sites that offer used phones could be a program that scans the phone's function.

One could design a program (or modify an already existing one) that runs tests on the phone such as stress tests for CPU and GPU, measures average battery life and time to open certain apps. This information as well as device model could then be directly uploaded to a site that offers people to sell used mobile phones. In combination with pictures of the phone, the buyer would have a good idea of the phone's capabilities and may be more inclined to trust the vendor. For this to work, second hand sites would need to implement support for this program and offer a direct connection to prevent scams.

While this design idea would not fully solve the problem, it may help to increase the trust in used phones and give buyers a chance to have a glimpse how the phone will really perform.

CONCLUSION

A survey was made to gather data from around the world on mobile phone use, behaviour with replacement including disposal and values in a mobile phone was made. This was followed up by an interview with 12 people. The qualitative data was then analysed and using that, implications or design ideas were created. From the data, some opportunities and challenges were identified like that people are still often storing their phones, do not know how to recycle but want to, that the subsidies on mobile phone are on the decline and that phones are often replaced because they become slow. The data was compared to a similar paper in 2008 to potentially show trends and changes. Some implications were made on these findings and a few design ideas were created that could encourage further work in this field. One of these ideas is to create a hub to inform people on what they can do with their old phones. Other ideas depend on the economic side of the findings and propose ideas that may be profitable and sustainable at the same time.

FUTURE WORK

There are several ways this work could be extended. For one, the topic could be looked at from the same angle but with different factors. The participants here were scattered around the world and were too few to have a representative group from one region or age group. It would be interesting to know how the behaviour differs with age/region and maybe learn of new ideas that may already be implemented in some countries.

Another way of extending this is to further analyse the aspect of keeping phones and how to motivate and inform people to recycle their unused phones. Different software ideas like the ones suggested here could be implemented and tested to see if people could be educated about phone recycling and if it would cause a change in their actions.

One interesting point to extend on would be to investigate the change in phone subsidies and see if it really is as drastic as it seems from the participants here. There, different countries could be looked at and one could compare the mobile phone market of counties that have fully gotten rid of phone subsidies to those who where it is still offered. It would also be interesting to examine how the demand for different phones changes over time with the reduction of such subsidies. A last point regarding this would be to further examine the chances for new upcoming ideas that are more sustainable in this changing environment.

A different approach to extend this work would be to research the secondary phone market further and see if a change in the contract subsidies would impact the sustainability. Additionally, research to reduce distrust in used phone sellers could be made and one could investigate if there is demand for more local second-hand stores. To that, one could expand on seeing how new design ideas can increase the resale value of phones.

Lastly one could test the different design ideas for making phones more resilient against getting too slow and expand that with new ideas. This could be made in tandem with new projects that are trying to penetrate the market with fresh ideas.

BILBLIOGRAPHY

- [1] Rob van der Meulen, "Gartner Says Worldwide Smartphone Sales Grew 9.7 Percent in Fourth Quarter of 2015", <https://www.gartner.com/newsroom/id/3215217>, Accessed 22.02.2017
- [2] "Current world population (ranked)", http://www.geohive.com/earth/population_now.aspx, Accessed, 20.02.2017
- [3] Jacob Poushter, "Smartphone Ownership and Internet Usage Continues to Climb in Emerging Economies" <http://www.pewglobal.org/2016/02/22/smartphone-ownership-and-internet-usage-continues-to-climb-in-emerging-economies/> Accessed 22.02.2017
- [4] Fishbein, B. (2002). "Waste in the wireless world." 1st ed. New York: INFORM.
- [5] Elaine M. Huang, Khai N. Truong. « Breaking the disposable technology paradigm: opportunities for sustainable interaction design for mobile phones." Proc. CHI '08 Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. Pages 323-332
- [6] Martin Woolley. "Choreographing Obsolescence – Ecodesign: the Pleasure/Dissatisfaction Cycle." Proc.DPPI '03 Proceedings of the 2003 international conference on Designing pleasurable products and interfaces. Pages 77-81
- [7] Eli Blevis. "Sustainable Interaction Design: Invention & Disposal, Renewal & Reuse." CHI '07 Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. Pages 503-512
- [8] Eric P.S. Baumer, M. Six Silberman. "When the Implication Is Not to Design (Technology)." CHI '11 Proceedings of the SIGCHI Conference on Human Factors in Computing Systems Pages 2271-2274
- [9] Jennifer C. Mankoff, Eli Blevis, Alan Borning, Batya Friedman, Susan R. Fussell, Jay Hasbrouck, Allison Woodruff, Phoebe Sengers. "Environmental Sustainability and Interaction". CHI EA '07 CHI '07 Extended Abstracts on Human Factors in Computing Systems Pages 2121-2124
- [10] Christian Remy, Silke Gegenbauer, Elaine M. Huang. "Bridging the Theory–Practice Gap: Lessons and Challenges of Applying the Attachment Framework for Sustainable HCI Design." CHI '15 Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems. Pages 1305-1314

- [11] William Odom, James Pierce, Erik Stolterman, & Eli Blevis. "Understanding Why We Preserve Some Things and Discard Others in the Context of Interaction Design." CHI '09 Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. Pages 1053-1062
- [12] Elaine M. Huang, Eli Blevis, Jennifer Mankoff, Lisa P. Nathan, Bill Tomlinson. "Defining the Role of HCI in the Challenges of Sustainability." CHI EA '09 CHI '09 Extended Abstracts on Human Factors in Computing Systems. Pages 4827-4830
- [13] Bates, O, Lord, C, Knowles, B, Friday, A, Clear, A & Hazas, "(un)sustainable growth of digital technologies in the home." Proceedings of the Third International Conference on ICT for Sustainability (ICT4S). Atlantis Press, 2015.
- [14] Kristin Hanks, William Odom, David Roedl, & Eli Blevis. "Sustainable Millennials: Attitudes towards Sustainability and the Material Effects of Interactive Technologies." CHI '08 Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. Pages 333-342
- [15] Elaine M. Huang, Koji Yatani, Khai N. Truong, Julie A. Kientz, Shwetak N. Patel. "Understanding Mobile Phone Situated Sustainability: The Influence of Local Constraints and Practices on Transferability". Journal IEEE Pervasive Computing archive. Volume 8 Issue 1, January 2009. Pages 46-53
- [16] Xiao Zhang, Ron Wakkary. "Design Analysis: Understanding E-waste Recycling by Generation Y." DPPI '11 Proceedings of the 2011 Conference on Designing Pleasurable Products and Interfaces. Article No. 6
- [17] Entner, R. "International comparisons: the handset replacement cycle", Recon Analytics (<http://mobilefuture.org/wp-content/uploads/2013/02/mobile-future>. Accessed on 14/01/2017].
- [18] iangkai Zheng, Kusheng Wu, Yan Li, Zongli Qi, Dai Han, Bao Zhang, Chengwu Gu, Gangjian Chen, Junxiao Liu, Songjian Chen, Xijin Xu, Xia Huo. "Blood Lead and Cadmium Levels and Relevant Factors Among Children from an E-Waste Recycling Town in China." Environmental Research 108(1):15-20
- [19] Adriano Michelotti Schroeder, Geraldo C. de Oliveira Neto, Washington Carvalho de Sousa, Ivanir Costa. "Recycle and Reuse Process of E-Waste (Printed Circuit Boards) in Brazil: A Case Study." MEDES '15 Proceedings of the 7th International Conference on Management of computational and collective intelligence in Digital EcoSystems Pages 214-220.
- [20] Rob Comber, Anja Thieme. "Designing beyond habit: opening space for improved recycling and food waste behaviors through processes of persuasion, social influence and aversive affect." Personal and Ubiquitous Computing archive Volume 17 Issue 6, August 2013. Pages 1197-1210

- [21] Pascal Lessel, Maximilian Altmeyer, Antonio Krüger. Analysis of Recycling Capabilities of Individuals and Crowds to Encourage and Educate People to Separate Their Garbage Playfully. CHI '15 Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems. Pages 1095-1104
- [22] John Vidal, The Observer, "Toxic 'e-waste' dumped in poor nations, says United Nations", <https://www.theguardian.com/global-development/2013/dec/14/toxic-ewaste-illegal-dumping-developing-countries> . Accessed 23.01.2017
- [23] Silke Gegenbauer, Elaine M. Huang. Inspiring the Design of Longer-lived Electronics through an Understanding of Personal Attachment. DIS '12 Proceedings of the Designing Interactive Systems Conference. Pages 635-644
- [24] Phil Turner, Susan Turner. "My Grandfather's iPod: An investigation of emotional attachment to digital and non-digital artefacts." ECCE '11 Proceedings of the 29th Annual European Conference on Cognitive Ergonomics. Pages 149-156
- [25] Sunyoung Kim, Eric Paulos. "Practices in the Creative Reuse of e-Waste." CHI '11 Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. Pages 2395-2404
- [26] Jina Huh, Kevin Nam, Nikhil Sharma. "Finding the Lost Treasure: Understanding Reuse of Used Computing Devices" CHI '10 Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. Pages 1875-1878
- [27] Fairphone. <https://www.fairphone.com/en/>
- [28] Somya Joshi, Teresa Cerratto Pargman. "In Search of Fairness: Critical Design Alternatives for Sustainability." AA '15 Proceedings of The Fifth Decennial Aarhus Conference on Critical Alternatives. Pages 37-40
- [29] Jain, R., Wullert J. , "Challenges: Environmental Design for Pervasive Computing Systems" MobiCom '02 Proceedings of the 8th annual international conference on Mobile computing and networking. Pages 263-270
- [30] Google Forms, <https://www.google.com/forms/about/>
- [31] Survey Planet, <https://surveyplanet.com/>
- [32] Surveymonkey, <https://www.surveymonkey.net>
- [33] Jacob Kastrenakes, Jan 11 2016, "Two-year phone contracts are now dead at all major US carriers" <http://www.theverge.com/2016/1/11/10749160/sprint-kills-two-year-phone-contracts>. Accessed 10.03.2017

[34] Thomas Gryta, Wsj, "Americans Keep Their Cellphones Longer"
<https://www.wsj.com/articles/americans-keep-their-cellphones-longer-1461007321>
accessed 09.03.2017