UNIVERSITY OF LJUBLJANA | FRI Faculty of Computer and Information Science

Smartphone Lifecycles and E-Waste Awareness Among Students in Slovenia

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Subject: Sustainable Computing
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List of Abbreviations

EoL End-of-life. 13

EU European Union. 2, 12

FMF Faculty of Mathematics and Physics. 4, 5

FRI Faculty of Computer and Information Science. 4, 5

SDG Sustainable Development Goals. 2, 3

UN United Nations. 2

WEEE Waste electrical and electronic equipment. 2

1 Introduction

This project investigates how university students manage smartphones throughout their lifecycle from purchase to disposal and how these decisions relate to environmental awareness and E-waste generation. The aim is to identify student patterns in device replacement, reuse, repair, recycling, and disposal, while also exploring the motivations, barriers, and levels of knowledge that shape sustainable or unsustainable behaviour. The results of the study will contribute to a better understanding of E-waste generation among young consumers and support the development of initiatives that promote responsible smartphone use, repair, and recycling in Slovenia. The project also highlights existing programmes related to E-waste and emphasises the significant role of the European Union (EU) in shaping legislation in this area.

2 Theoretical framework of the E-waste problem

2.1 E-waste

Directive 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on Waste electrical and electronic equipment (WEEE) [3] in Article 3 of the directive defines E-waste as *WEEE, in which W stands for waste and electrical and electronic equipment or EEE means equipment which is dependent on electric currents or electromagnetic fields in order to work properly and equipment for the generation, transfer and measurement of such currents and fields and designed for use with a voltage rating not exceeding 1 000 volts for alternating current and 1 500 volts for direct current.*

2.2 Achieving SDG with E-waste

When conducting research today, it is appropriate to refer to the Sustainable Development Goals (SDG) shown in figure 1 established by the United Nations (UN). These include 17 goals and 169 targets developed as part of a global initiative aimed at protecting our planet. The SDG form a core component of the 2030 Agenda for Sustainable Development. Their focus extends not only to human well-being but also to other living beings and the environment as a whole (cited from [10]). E-waste management can play a significant role in supporting progress toward several of the goals outlined in the SDG 2030 framework. After examining the article [10], it is possible to identify the SDGs that are directly and indirectly affected by E-waste and E-waste management.

Directly affected SDGs with descriptions for each SDG:

- *6 Clean Water and Sanitation*: [6] emphasizes that E-waste can be toxic, is not biodegradable and accumulates in the environment, in the soil, air, water and living things. Improper handling of e-waste is resulting in a significant loss of scarce and valuable raw materials, including such precious metals as neodymium (vital for magnets in motors), indium (used in flat panel TVs) and cobalt (for batteries). Almost no rare earth minerals are extracted from informal recycling.

- *13 Climate Action*: [6] notes that in 2015, the extraction of raw materials accounted for 7% of the worlds energy consumption. The carbon footprint of every device produced is contributing to human-made global warming.

- *14 Life Below Water* and *15 Life on Land*: [10] says that when informal recycling[1] takes place, the processes involved often use and produce various hazardous substances. These substances are frequently disposed of in water bodies or dumped in remote areas of land. When they leak into the environment without protection or regulation, they harm living organisms both on land and in water, directly relating to SDG 15 (Life on Land) and SDG 14 (Life Below Water).

Indirectly affected SDGs with descriptions for each SDG:

- *3 Good Health And Well Being*: This SDG is directly influenced by the impacts on SDGs 6, 13, 14, and 15. Encouraging formal Ewaste recycling (regulated and environmentally responsible recycling) reduces the damage done to water bodies and land areas, which are essential sources of food and water for sustaining life. (Extracted from [10])

- *8 Decent Work and Economic Growth*: [10] states that the use of proper recycling methods also promotes a circular economy. It supports responsible consumption and production, while the Ewaste recycling sector creates job opportunities and decent work.

- *11 Sustainable Cities and Communities*: [10] further explains that a city or community with wellimplemented Ewaste management practices can contribute positively to a greener environment and to the national economy. This is achieved through effective Ewaste collection and increased awareness of the issue.

- *12 Responsible Consumption and Production*: [6] reports that Recycled metals are two to 10 times more energy efficient than metals smelted from virgin ore. Furthermore, mining discarded electronics produces 80% less emissions of carbon dioxide per unit of gold compared with mining it from the ground. When the carbon dioxide released over a devices lifetime is considered, it predominantly occurs during production, before consumers buy a product. This makes lower carbon processes and inputs at the manufacturing stage (such as use recycled raw materials) and product lifetime key determinants of overall environmental impact.

Figure 1: This figure was taken from the webiste *https://www.lawcode.eu/en/blog/sustainable-development-goals-sdgs/* on 8. January 2026

[1]Informal recycling uses acids to separate various substances found in an electronic device. The disposal of used acids is a major concern. The untreated acids are either disposed in water bodies or are thrown in remote pieces of land. Formal recycling uses eco-friendly ways of recycling E-waste and recovering materials. (Cited from [10])

3 Survey

For this project, a survey titled *Survey on the life cycle of smartphones and awareness of e-waste among students* was conducted. It was distributed among students of the Faculty of Computer and Information Science (FRI) and the Faculty of Mathematics and Physics (FMF) at the University of Ljubljana via student-run Discord servers that all students at the faculties have access to.

3.1 Related Work and Main Objectives

Research on smartphone lifecycles and E-waste behaviour has been carried out in several countries. We focused particularly on research within university environments. A key reference for this survey was the study conducted in Germany and China [4], which examined how students dispose of old mobile phones and included the question *"What do you normally do with old and unused mobile phones?"*. This question, together with its answer structure, served as the basis for designing our own question on disposal behaviour. Similar studies from the UK [5] and Turkey [8] provided additional insight into cultural and regional differences in disposal habits, awareness levels, and motivations behind E-waste management choices.

Beyond disposal behaviour, several other sources informed different aspects of our survey design. Articles such as [1, 7, 9] focused on circular economy principles, device lifecycles, and the environmental impact of smartphone production. These works helped shape the questions related to repair, reuse, and replacement patterns. Studies examining behavioural factors and local recycling practices [2, 11, 12, 13] contributed to the formulation of questions addressing awareness, perceived barriers, and the role of institutions in promoting responsible E-waste management.

While previous studies primarily focused on national-level comparisons or broad demographic groups, our work differs by concentrating specifically on students from two technical faculties within a single university. This narrower focus allows for a more detailed examination of how students in highly technical fields understand and manage smartphone E-waste, and whether their behaviour aligns with findings from international studies.

3.1.1 Main Objectives

Based on the reviewed literature, the survey was designed to address the following key points:

- determining the disposal method of an old mobile phone,
- identifying the main reasons for choosing a specific disposal method,
- assessing awareness of what E-waste is.

Additional objectives included exploring how many old mobile devices students keep at home, what motivates their chosen disposal behaviour, and what actions they believe their faculty or university could take to improve E-waste management.
From the related work, several expectations for the survey results were formed. Studies from Germany and China [4], the UK [5], and Turkey [8] suggest that:

- *More than half of students tend to keep their old mobile device at home.*
- *This disposal (or storage) method is chosen primarily due to convenience.*
- *Students generally report being aware of E-waste.*

3.2 Survey Structure

The survey included 13 mandatory questions (14 for some participants) and 2 optional open-ended questions intended to gather students' opinions on two topics. Most of the mandatory questions (11 out of 14) were single-answer multiple-choice questions. The remaining three were either short-answer questions or multiple-choice questions with several possible answers. All of the survey questions are available in the appendix.

The survey was divided into three sections. The first focused on demographics, asking about age, gender, faculty of study, and level of study. The second section focused on students mobile phone purchasing and disposal practices. The final section focused on awareness of e-waste.

3.3 Data Collection

The survey was opened for admitting answers from 20. December 2025 and closed on 5. January 2026. In total 114 students from the 2 faculties submitted answers to the survey in this period. From these 68 students were from FMF, 46 were from FRI.

3.4 Results

3.4.1 Demographics

Out of 114 participants, 29 reported being female, 78 male, and 7 either did not want to answer or answered with *Other*. 95 students reported being undergraduate students, 16 graduate students, and 3 doctoral students. Table 1 shows the faculty and gender distribution of survey participants. Figure 2 shows the age distribution with different colors representing students from the faculties.

Table 1: Table with how many students in total answered the survey from each faculty and what was their gender.

Faculty	Total	Male	Female	I don't want to answer	Other
FMF	68	45	20	2	1
FRI	46	33	9	4	0

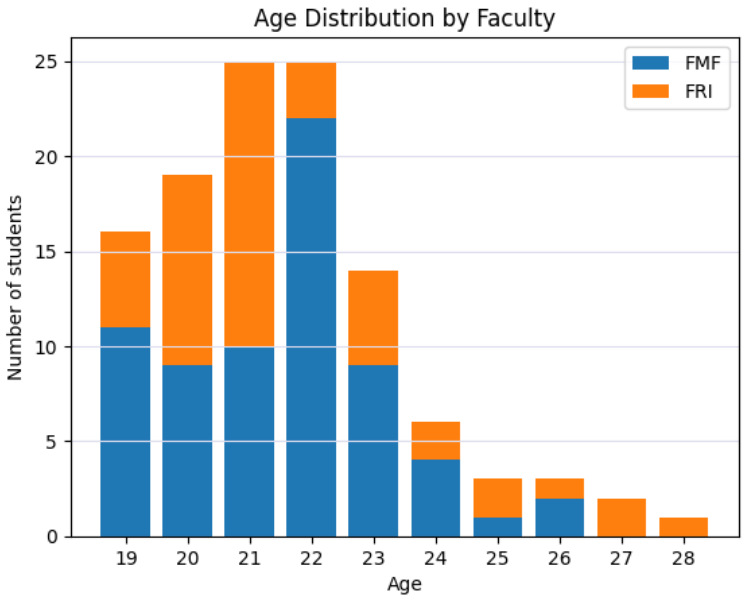

Figure 2: Histogram of the age distribution of participants with different colors representing the 2 faculties.

3.4.2 Personal Mobile Device

The survey showed that 93 participants owned a phone from one of the following brands (listed from most to least common): Samsung (48 participants), Apple (25 participants), and Xiaomi (20 participants). 35% of students reported that their device (at the time of purchase) cost somewhere between 200 EUR and 400 EUR. Taking this into account, 64% of students own a mobile device that was purchased for less than 600 EUR.
A large majority of participants (93 students) stated that they plan to keep their current device until it becomes unusable.
When analysing the reasons for replacing a previous mobile device, the survey revealed the following: a significant portion of participants felt the need to replace their phone due to the following reasons (with percentages indicating the share of the entire participant group who selected each as the most likely reason): *Irreparable damage or damage that is too expensive to repair* (38%), *Slow performance / obsolescence* (27%), *Poor battery* (15%), and *I want a newer model* (4%). 13% of all participants who answered this question provided their own reason. Among these, the majority mentioned that their reason for replacement (in one way or another) included either of the following:

- exchanging phones with parents (either parents giving the phone to the student or the student giving the phone to a parent),
- receiving a new phone as a gift or for free, which made the old phone unnecessary.

Other participants described various forms of physical damage, device obsolescence, or operating system obsolescence as their reason for replacement.

3.4.3 How many phones are kept at home?

After an old mobile device is no longer in use, it has to be properly disposed of. Many such methods are available to students, yet a large proportion of them choose only one option. The given hypothesis that this option is storing the device at home was proved to be correct.

From Figure 3 it is shown that 86 students stated that they kept their previous device at home. These represent 74 % of all the participants. These students were then asked how many old mobile devices they currently have at home. 64 students estimated having between 1 and 3 devices, 15 estimated between 4 and 6, and only 6 students estimated having more than 6 devices. Out of all the students, 14 stated that they gave their device to friends or family members. **Even though many recycling points are available, only 2 students reported taking their phone there.**

An interesting point of investigation in this survey is why students choose one disposal method over another. The question What did you do with your previous phone after the replacement? aimed to determine exactly this. Students were able to select multiple answers and also provide their own. Since a large number of students stated that they kept their old device at home (86 students), Figure 4 illustrates how their reasons were distributed. Alongside the expected reason of comfort and convenience, all other listed reasons for keeping an old device at home appeared with similar frequency, with environmental responsibility and financial benefit being the outliers, as fewer than 10 students selected either of them. Among these, Lack of suitable disposal sites in my area was selected by the largest number of students (22 students). Within the Other category, 21 students mostly explained that they keep these devices as backups, use them for other purposes, or are simply too lazy to dispose of the device properly at the time of replacement and later forget about it.

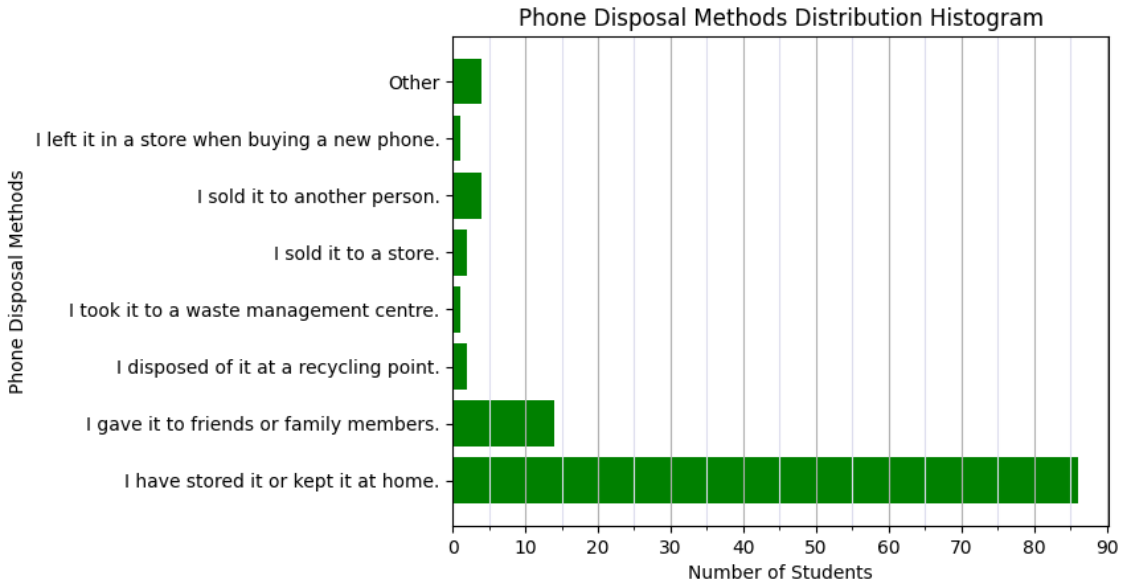

Figure 3: The histogram shows what students did with their old mobile device. Under *Other*, students stated that they kept their device at home, tried to fix it themselves, or repurposed it for further use.

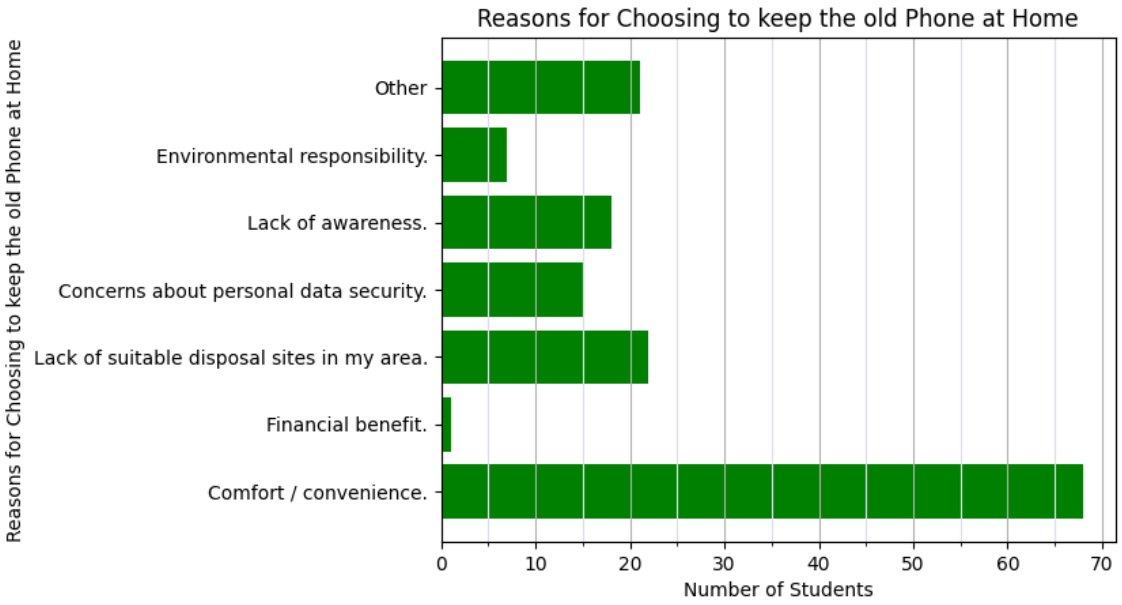

Figure 4: The histogram shows why students chose to keep their old device at home instead of disposing of an old mobile device.

3.4.4 Awareness about E-waste

The last section of the survey focused on students awareness of E-waste. It also aimed to determine whether students know what counts as E-waste. Awareness was assessed through the question *Have you heard of waste electrical and electronic equipment (E-waste) before taking this survey?*. To this question, 84% of students answered *Yes*. From this, we can see that there is still a considerable portion of students who, despite living in a digital age where almost everything qualifies as E-waste, are still not aware of E-waste and consequently E-waste management.

From Figure 5 it is clear that almost all students identified smartphones, laptops, and tablets as E-waste (more than 100 participants selected these options). A smaller but still significant number of students (80 out of the 114 surveyed) also classified batteries, household electronic appliances, and chargers and cables as E-waste. Only 11 students selected the option indicating that they were unsure what belongs in E-waste. These answer choices were designed so that someone knowledgeable about E-waste would select all of the listed categories, as all of them indeed belong to E-waste.

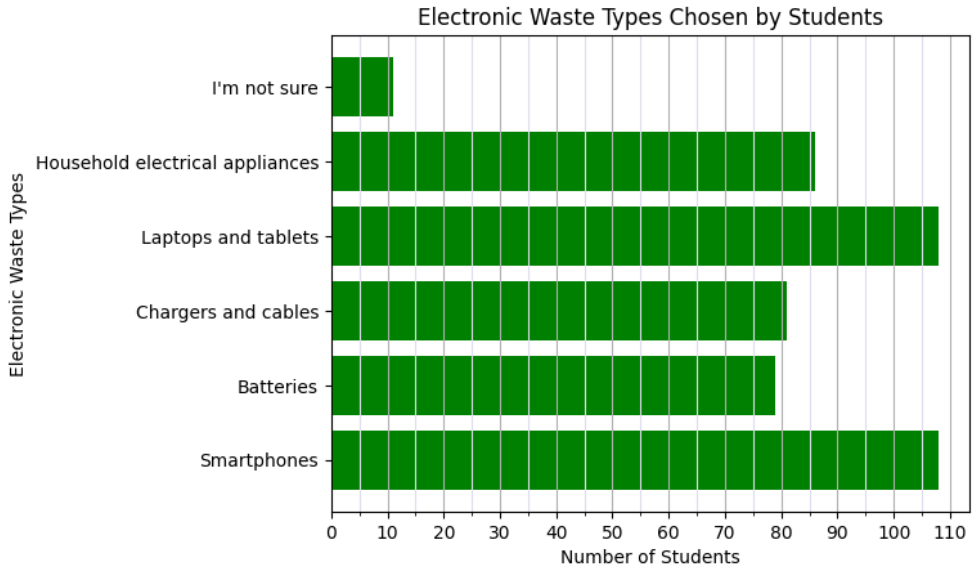

Figure 5: The histogram shows which groups of E-waste the questioned students recognized as E-waste.

3.4.5 Students' Opinions

When examining the answers students provided to the last two nonmandatory, openended questions, some opinions were mentioned by multiple students.

The first question, *"What do you think is the main reason that students do not throw old phones into ewaste collection points?"*, revealed that many believe these collection points are not easily accessible or that students are not aware of their existence. Others pointed out that laziness, forgetfulness, and the lack of any tangible reward may lead students to choose the convenience of leaving a small mobile phone at home. Only a small number of students mentioned that old devices can still be used as backups, while also acknowledging that this is usually not the case in practice. It is important to note that several students mentioned that they get nothing in return, implying that the lack of incentives may discourage proper disposal.

The second question *"How do you think your faculty or university could contribute to improving knowledge about e-waste and the proper disposal of old phones?"* aimed to gather opinions and suggestions on how the faculty or the university could help improve this situation. This question was included because students spend most of their time at the faculty, making it their primary connection to a larger institution capable of influencing change. Some of the most common suggestions included:

- *placing special bins at the faculty where students could drop off their phones when coming to lectures*,
- *creating posters and pamphlets*,
- *mentioning this topic in lectures or organising events related to ewaste disposal*, and
- *launching a campaign focused on this issue.*

3.4.6 Discussion

After reviewing the results of the survey, it is possible to state that the hypotheses predicted that students predominantly store old devices at home, that this choice is driven by convenience,

and that students generally possess basic awareness of Ewaste. It is important to note that no significant differences in phone disposal behaviour or E-waste awareness were observed between students from the two selected faculties. This outcome was expected due to the technical nature of both faculties. In both groups, the majority of students lacked knowledge about the available resources for old mobile phone disposal.
When comparing these key findings to other studies mentioned in [4], we can see that the results largely align with those from other countries. Table 2 presents a comparison of the proportion of participants who reported using this disposal (or storage) method when asked what they do with an old mobile phone.

Table 2: The table shows the percentage of students who reported storing an old mobile phone at home. It illustrates the similarity of results across studies conducted in different countries among university students.

Answer	Slovenia	Germany	China
Store at home.	74%	73.3%	72.4%

3.4.7 Limitations

Though this research provides interesting results and insights, several limitations exist. Firstly, the sample being limited to university students is a shortcoming of the study. An additional limitation is that all participants come from only two highly technical faculties. The survey section addressing E-waste awareness was relatively brief, which restricts the depth of conclusions that can be drawn. Expanding this part of the research could help determine the underlying causes of the low level of knowledge about E-waste disposal. Furthermore, extending the study to the entire university and comparing students from multiple fields of study could yield more diverse and representative results.

4 Deeper analysys of e-waste awareness

4.1 Why people don't use buyback programs?

From the survey results, we found that a lot of people don't use buyback programs. We wanted to see what are the reasons for that. We checked some of the buyback programs and got some interesting results. In Slovenia, there are only two buyback programs for smartphones that I found. The first buyback program is used by Telekom Slovenije, A1, Telemach and BigBang and is called "Risajkl". The runner of the program is a company called "Janus Trade d.o.o." and is mostly focused on promotions ran by Samsung, since they are importing Samsung devices.

By discovering only 2 buyback programs exist in Slovenia, we can conclude that demand for buyback programs is low. Same could also be deducted from the survey results, where most of the students said they keep their old phones In a drawer at home. These phones could be already recycled and their materials reused. These phones could also be dangerous at home, since phones are usually not stored properly and batteries could leak or even explode in some cases.

By conducting further research into buyback programs in Slovenia, I found they are not used often, mainly because of poor buyback prices. For example a 3 year old Google Pixel 6a phone in almost perfect condition is bought back for only 40 euros. Or my personal iPhone 16 pro Max, which is only 1 year old, is bought back for only 500 euros. This is a very low price, since the phone itself costs 1300 euros when bought new.

Buyback programs are a great way for people to get something in return for their old devices, but they tend to avoid it because of low pricing. I would recommend that companies that use these programs create some kind of subsidy program from their side to encourage people to consider selling their old phone instead of keeping it in their drawer.

4.2 Why do people keep their devices at home?

From the survey results, we found that a lot of people keep their old phones at home in a drawer. It is understood that people keep one maybe two old phones at home as a backup device in case their current phone breaks or gets lost. But some people keep even more and that is not necessary, since not more than one phone will be used at most and keeping those old phones could be very dangerous. Most of people eventually forget about these old phones and they just sit in a drawer for years. Some answers in survey also implied that the value of the phone is not high enough to encourage people to sell them, but they give no reason on why they don't recycle them. Some of answers also implied that people do not know how or where to recycle these phones. Usually complaints come from distance needed to travel just to drop off a phone for recycling. Most of collection points are located in urban areas so people who live further away don't see the point of traveling just to drop off a phone for recycling.

4.3 Recycling

Recycling is one of the crucial steps in managing e-waste from mobile phones. Old phones contain a lot of rare earth materials that can be recycled and reused in the production of new devices. In other words, recycling old phones can reduce the need for mining new materials, and thus have significant positive impacts on the environment. We can also reuse other materials like glass, plastic and metal from phones that would otherwise seat in peoples drawers or end up in landfills.

To further address the matter, we conducted a research on ways for Slovenian citizens to recycle their phones. Slovenians have a very good networks of collection points for their old devices and generally do not need to travel far distances to reach a recycling point. Namely

we have There are several ways to do this. First, all technology resellers are required by law to recycle old phones. This includes big stores like BigBang, Merkur and others. There are also special collection points for electronic waste in landfills and special collection points in some recycling islands. ZEOS a company owned by some Slovenian distributors and stores is the company that arranges the appearance of those collection points and is responsible for e-waste management in Slovenia.

5 Possible solutions to improve recycling rates

European union has already taken some important steps to help improve those rates and establish stable ground for circular economy. Additionally improving recycling rates is important to reach quite a few sustainable development goals like climate action and responsible production and consumption. However, to convince people to recycle their old phones is not an easy task. Additionally there are several possible solutions that could help improve recycling rates among citizens, students in particular.

5.1 European 2012 WEEE directive

European union has already began it's war against electronic waste with the 2012 European WEEE directive, which directs union countries on how to handle electronic waste, how to establish their collection points and how distributors and shops are responsible for handling electronic waste. In Slovenia this directive is implemented using ZVO-2 law and implements all important factors of the directive like collection, handling, recycling and reuse of electronic waste. It was one of most important steps EU took to establish stable and reliable network of collection and recycling points. It also sets clear minimal goals for EU member states on recycling and reuse of EEE to prevent as much waste to end up at landfills as possible. Requirement of special marking on electronic devices further alerts people to be careful when disposing of such item into bin, since it does not belong there.

5.2 Increased awareness campaigns

One of the most important steps is to make students aware of e-waste problem. From our survey, it is possible to deduce that 84% of students are aware of the e-waste problem, but there were a few that were not familiar with the term e-waste. Awareness campaigns could be conducted at universities and on social networks. There could also be workshops and lectures held on topic of e-waste and recycling. There should also be some notice on dangers of keeping older devices at home. Improper storage and handling of older devices could result in battery leakage, household damage or even fire if battery or any other component is disturbed into unstable position.

5.3 Improved accessibility to recycling points

Another possible solution is to improve accessibility to recycling points. This could be done by increasing the number of collection points at universities and other public places. Directive for WEEE already burdens countries to install municipal collection points [3], but as seen from the survey these collection points are located too far for some students. Most of Slovenian municipals already installed multiple collection points across their towns, and added them to a map on ZEOS website [15]. Most people also are not aware that all Slovenian and European sellers of electronic devices are required by law to collect old devices that are decommissioned. These shops should have a sticker on them that say "COLLECTION POINT" or something

similar to inform more people that WEEE can be left there and are sometimes actively trying to hide it.

5.4 Financial or other incentives for recycling old devices

One idea that keeps people in question are financial incentives for recycling End-of-life (EoL) devices. This would mean giving students some type of financial push that would encourage them to bring their old devices in return for some discounts at shops. A research paper from 2019 gave a great example of a bonus card system that would give students bonus points that would accumulate over multiple recycled devices. These points could than be used as a discount for a new device or to buy something completely different [14].

6 Conclusion

E-waste is a growing environmental challenge, and understanding how students manage their smartphones is important for reducing its impact. This study set out to examine disposal habits, motivations, and awareness among students from two technical faculties. The survey confirmed the initial expectations: most students keep old phones at home, convenience is the main reason for this choice, and general awareness of E-waste exists, though it does not consistently lead to responsible disposal.

These findings show a clear gap between awareness and action, largely due to limited knowledge of collection points and a lack of incentives. For Slovenian students in particular, improving accessibility and visibility of E-waste disposal options could significantly increase proper recycling. Universities can support this by placing dedicated collection bins on campus, raising awareness through lectures or campaigns, and encouraging responsible behaviour. Strengthening these efforts would help ensure that students are not only informed about E-waste but also equipped to act sustainably.

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7 Author Contributions

Table 3: Table with project parts and task and who contributed in what way.

Task	**Author/Authors**
Project proposal	Nina and Mark
Preliminery and main survey design, distribution and analysis	Nina
Compiling of resources	Nina
Sections 1 through 3 on project report	Nina
Sections 4 and 5 on project report	Mark
Design of poster	Mark
Research on ZEOS, recycling points and Buyback programs	Mark

A Survey Questions

A.1 Mandatory Questions

1. How old are you? *(Short answer)*
2. What is your gender? *(Multiple choice)*
3. Which faculty are you studying at? *(Multiple choice)*
4. At what level of study are you currently? *(Multiple choice)*
5. What brand of phone are you currently primarily using? *(Multiple choice)*
6. What was the price of the phone from the previous question at the time of purchase? *(Multiple choice)*
7. What year did you buy your current primary phone? *(Multiple choice)*
8. When do you intend to replace your current primary phone? *(Multiple choice)*
9. Why did you replace your previous phone? *(Multiple choice)*
10. What did you do with your previous phone after the replacement? *(Multiple choice)*
11. How many used phones do you currently have stored at home? *(Multiple choice)*
12. Why did you choose this method of disposing of the used device? *(Multiple choice multiple answers allowed)*
13. Have you heard of waste electrical and electronic equipment (e-waste) before taking this survey? *(Multiple choice)*
14. Which of the listed items, in your opinion, fall under e-waste? *(Multiple choice multiple answers allowed)*

A.2 Non-mandatory Questions

15. What do you think is the main reason that students do not throw old phones into e-waste collection points? *(Open-ended)*
16. How do you think your faculty or university could contribute to improving knowledge about e-waste and the proper disposal of old phones? *(Open-ended)*