OULU UNIVERSITY OF
APPLIED SCIENCES

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Energy efficient use of the smartphones

Student Survey for the Oulu University of Applied Sciences

Energy efficient use of the smartphones

Student Survey for the Oulu University of Applied Sciences

Turkka Salmi
Bachelor's Thesis
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ABSTRACT

Oulu University of Applied Sciences
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As the number of smartphones and their users are swiftly increasing in the future, it is crucial to find various ways for using smartphones sustainably and energy efficiently. Nowadays the duration of the battery is limited because of its size and weight, which is why the energy efficient use of the smartphone is essential. Recently, the endurance of battery lifetime has been gaining popularity as a significant feature among smartphone users.

The purpose of the thesis was to find out various methods of using smartphones in an energy efficient way. The thesis introduces the features of smartphone that can help manage battery consumption and analyses how smartphone user behaviour affects the battery consumption. Data for the thesis were collected from topic related literature, scientific articles, online sources and conducted research about the topic. With the survey, it was examined whether the respondents of the survey used their own smartphones energy efficiently. The respondents were students from different degree programmes in the Oulu University of Applied Sciences.

As a result of the thesis it was discovered that smartphones have various features and functions that drain battery life. Furthermore, smartphones have many different settings that can assist with managing battery consumption. In addition, the way that smartphones battery is being charged affects profoundly the overall endurance of the battery. With the help of the survey essential information was gathered of user behavior and the efficiency of smartphone use. It was found out that even though the majority of the respondents knew how to use smartphones energy efficiently, several of the respondents were not necessarily doing so. There were also some notable differences when comparing the results of the survey between the replies of male and female respondents.

Keywords: smartphone energy efficiency, battery consumption, smartphone user behavior

CONTENTS

1 INTRODUCTION

Smartphones have become a remarkable part of our everyday life and accompany us everywhere we go. Modern smartphones have multiple features and functionalities that allow us not only to communicate with each other but also to use a smartphone almost like a personal computer. In our daily lives smartphones are being used for example for communication, audio and video streaming, web browsing and gaming. The richness of functionalities puts pressure on battery lifetime and emphasizes the importance of battery energy efficiency. In order to achieve energy efficiency of smartphones, it is crucial to understand where and how the energy is spent. (Carroll & Heiser 2010, cited 31.8.2017).

The purpose of the thesis is to find out ways to use smartphones in an energy efficient manner. The thesis introduces the features of a smartphone that can help manage battery consumption and also analyses how smartphone user behaviour affects the battery consumption. With the survey, it is examined whether the respondents of the survey use their own smartphones energy efficiently. The respondents were students from different degree programmes in the Oulu University of Applied Sciences, the School of Business and Information Management. The theoretical part and references for the thesis were gathered from topic related literature, scientific articles, online sources and conducted research about the topic.

The thesis aims to answer to the following questions:

- What are the ways to use smartphones energy efficiently?
- Do the respondents of the survey have general information on how to use smartphones in an energy efficient way?
- Are the respondents of the survey using their smartphones in an energy efficient way?

The topic of the thesis was chosen because it is a very current issue. It is interesting to find out how the students of the Oulu University of Applied Sciences are using their smartphones as these students have presumably sufficient knowledge and experience of the smartphone energy consumption. It is also interesting to examine the attitudes behind the smartphone user behavior and how it affects the overall use of the smartphones.

2 ENERGY EFFICIENT USE OF SMARTPHONES

Nowadays smartphones play a significant role in our daily lives. Smartphones are being used in multiple activities, for example as a tool for communication, personal entertainment and work life (Chen, Chen, Ma & Fernandes 2013, cited 26.8.2017). It has been estimated that there are more than 3 billion smartphones in the world today. The number of smartphones is growing steadily every year whereas the mobile traffic generated by them is increasing excessively. (Cisco Visual Networking Index 2017, cited 10.9.2017).

As seen in a forecast study conducted by eMarketer (2013), it was estimated that the total amount of smartphone users is growing rapidly in the following years. According to the study, over half of the total mobile phone users will be using smartphones by the end of the year 2018. In the year 2018 there will be over 2.5 billion smartphone users in the world. As the number of smartphones and their users are firmly increasing in the future, it is crucial to find various ways for using smartphones sustainably and energy efficiently (Figure 1).

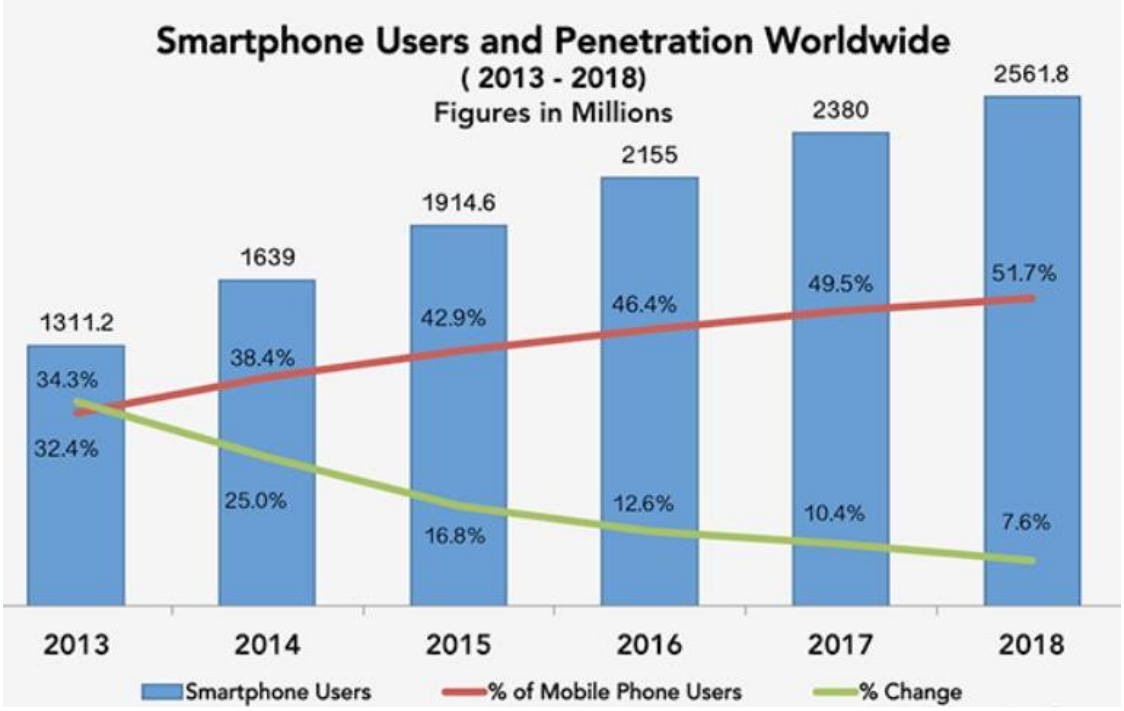

FIGURE 1. Worldwide Active Smartphone user Forecast 2013-2018 (eMarketer, Dazeinfo, Mahajan 2014 cited 16.10.2017)

2.1 Energy efficiency of smartphones

Majority of smartphones gain their energy from lithium-ion batteries that produce multiple times more energy than batteries of other kind of the same size. However, up-to-date battery technology shows that the options at the moment for increasing the battery life of smartphones is developing advanced, more energy sustainable mobile applications and operating systems. Additionally, it is also important to lower power consuming at the hardware level. (Vallina-Rodriguez & Crowcroft 2013, 179).

The capacity of smartphone battery is limited because of the size and weight of the battery. Therefore, the energy efficiency of the smartphone is essential for their use. Nowadays smartphones have plenty of multiple features and functions. This increases the requirements for battery capacity and the need for energy efficiency. For understanding the energy efficiency of the smartphone, it is important to examine which parts of the system use the energy and how much energy is consumed in different circumstances. (Carroll & Heiser 2010, cited 6.8.2017).

Regular mobile phone that does not use any smart applications can last for several days without charging. However, when used actively, a smartphone can hardly last for even one or two days without charging the battery. Smartphones use more energy compared with regular mobile phones even if smart applications are rarely used. Although smartphone battery capacity has increased, the duration of the battery is shorter compared to a regular mobile phone. (Brocanelli & Wang 2017, 2288). According to Rahmati, Qian and Zhong (2007, 265), 80% of smartphone users have been looking for numerous ways for increasing the battery lifetime of their smartphone.

The graphical capabilities of smartphones have improved excessively in the past few years. The advancement is largely possible with the development of Graphical Processing Unit (GPU) chipsets in smartphones. Rather than depending on the Central Processing Unit (CPU) for carrying out its graphical data, smartphones implement circuits for doing it more efficiently. More effective GPUs increase the battery consumption of the smartphone. These days smartphones have large, high resolution screens that enable more efficient way of processing graphical data. This results in higher energy consumption because of more pressure on the GPU. For this reason, battery performance can be increased by making GPUs more energy efficient. (Ahmad & Shihada 2015, 740).

One of the most important factors for a high energy consumption of a smartphone is its efficient multi-core application processor that is active during almost any smartphone activity. On average, smartphones are being used from one to three hours per day meaning smartphones are idle and not being used most of the time. One way of gaining an efficient battery duration could be inactivating the application processor when smartphone is not being used. (Brocanelli & Wang 2017, 2288).

2.2 Smartphone user behavior

For smartphone users there can be many inconveniences caused by the limited battery life of a smartphone (Xu, Liang, Peng, Liu & Wang 2017, 990). Smartphone users have various requirements for the features, functions and overall performance of their devices. Issues such as reputation of the brand and the endurance of the battery lifetime have also been gaining popularity as important aspects of the overall satisfaction among users. (J.D. Power and Associates 2012, cited 13.10.2017).

Some smartphones simply cannot last for a day in active use and therefore users may limit their smartphone use for the latter part of the day. Some users try to prolong battery life by turning off energy-consuming functionalities, such as GPS, Wi-Fi or 3G/4G. The user may also decrease the usage of some features or applications, for example Twitter, Google maps, e-mail or YouTube. One solution for the user is to carry a charging device, which can be seen as inconvenient. (Xu et al. 2017, 990).

Falaki, Mahajan, Kandula, Lymberopoulos, Govindan & Estrin (2010) conducted a study of smartphone usage. Using information from 255 users they studied the activities of the users, including communication and applications being used, and the impact on the energy consumption. In the study it was found out that the use of a smartphone varies extensively among users. The number of daily smartphone interactions can vary from 10 to 200, and the volume of received data per day may vary from 1 to 1000 MB. The variation between users is derived from the fact that users use smartphones for different reasons and with different density. For example, some users like to play or use map applications with their smartphones and these activities usually take longer time. Therefore, it is proposed that smartphone user behavior should be taken into account when trying to improve the energy efficiency of smartphones. (Falaki et al. 2010, 193–194).

Shye, Scholbrok, Memik and Dinda (2010) presented a six-month study that involved 25 people and their smartphone usage behavior with a particular Android G1 smartphone, HTC Dream. According to the research, users that participated in the study recharged their phones daily and used their smartphones until the battery was low. In ~20% of the cases, users recharged their smartphones when it was unplugged from the charger for more than four hours. Therefore, battery management plays a very important role in user experience of the smartphone. In the research, it was discovered that the users used smartphones actively 11% of the usage time and the phones were in the idle state for 89% of the time. Active phone usage consumed 53,7% of the system power whereas the idle state consumed 46,3%. It was also found out that the majority of the users did not adjust the display screen brightness of the smartphone or use any battery power management software. (Shye et al. 2010, 375–376).

2.3 Applications that drain battery life

Mobile applications have become highly popular hence the greatly increasing rate of smartphone adoption. Online mobile application markets (app marketplace portals) for example Google Play on Android and iOS App Store on Apple iOS have had a significant effect on discovering and using new mobile applications. (Xu, Erman, Gerber, Mao, Pang & Venkataraman 2011, 329). According to a statistical illustration by Statista & Mashable and source of data by Google's Our Mobile Planet (2013), it was discovered that globally on average smartphone user had installed 26,2 mobile applications, of which 20,6 were free applications and 5,6 paid applications (Figure 2).

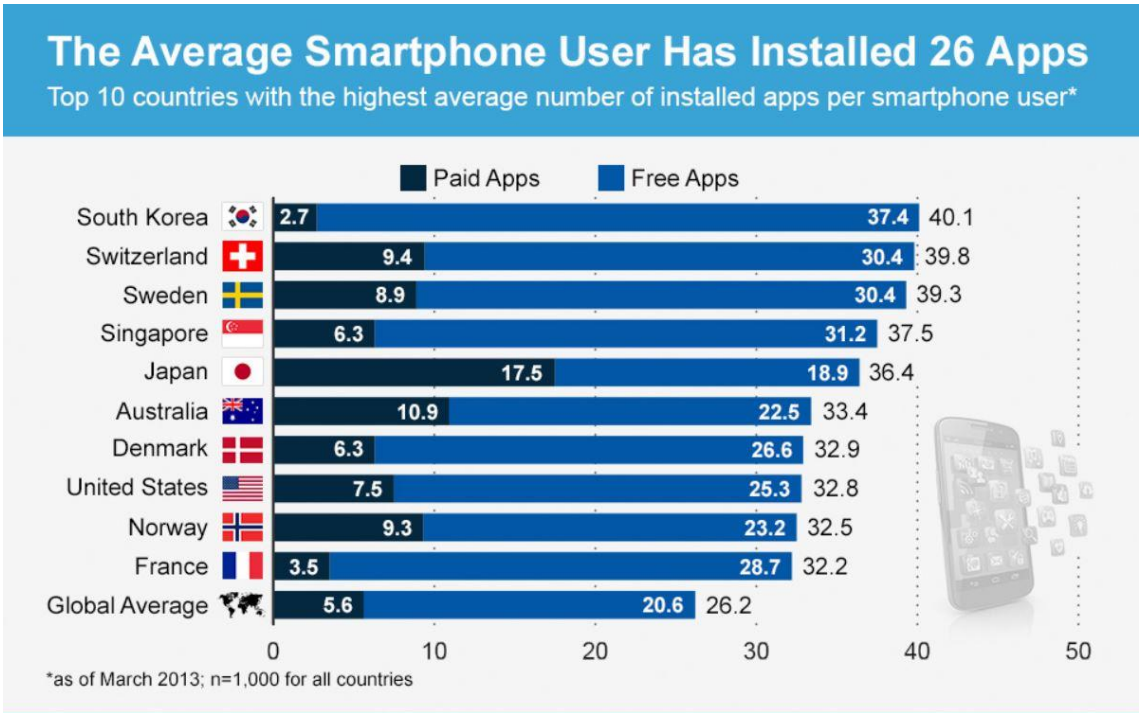

FIGURE 2. Average of installed free and paid applications (Statista, Mashable & Google: Our Mobile Planet 2013, cited 16.10.2017)

A substantial part of energy consumption of a smartphone is caused by applications. Applications for example download data, use sensors and display information. The components that use the majority of the energy, are related to the display, the CPU, the internet connection and the GPS sensor. (Hans, Burgstahler, Mueller, Zahn & Stingl 2015, cited 17.9.2017). The variation of smartphone applications ranges from basic 2D text based editors or web browsers to complex 3D high resolution multimedia streaming applications and mobile games. (Ahmad et al. 2015, 740).

As the use of smartphones has dramatically been increasing in the past few years, various Location-Based Applications (LBAs) have also been gaining popularity among smartphone users. These include for example several social media, entertainment and business management applications. LBAs frequently use GPS (Global Positioning System) applications, which severely reduces battery lifetime of the smartphone. (Zhuang, Kim & Singh 2010, 315).

Multimedia application usage covers an increasing amount of daily use of smartphones. These include video and image editing tools, games and video player applications. Display technology affects profoundly the power consumption of these applications. Therefore, it is not surprising that display technology and smartphone power management has recently been studied considerably. (Chen et al. 2013, cited 26.8.2017).

A study done by AVAST shows a list of Android applications that drained the most battery life, mobile data and storage space of the smartphone (Figure 3). The study showed that applications such as multimedia streaming application Spotify, instant messaging and multimedia sharing application Snapchat and social search application Tinder consumed battery life significantly. However, it was surprisingly noted that a spreadsheet creation and reading application Google Sheets together with an online reading and publishing application Wattpad consumed battery life heavily. Application data gathered in the study covered a certain period of time from July 2016 to September 2016. Data was gathered from more than three million anonymous Android users around the globe and included applications for the Android operating system. The study only contains data from Android applications in the Google Play that had over 50 000 users. (AVAST, Villinger 2016, cited 25.10.2017).

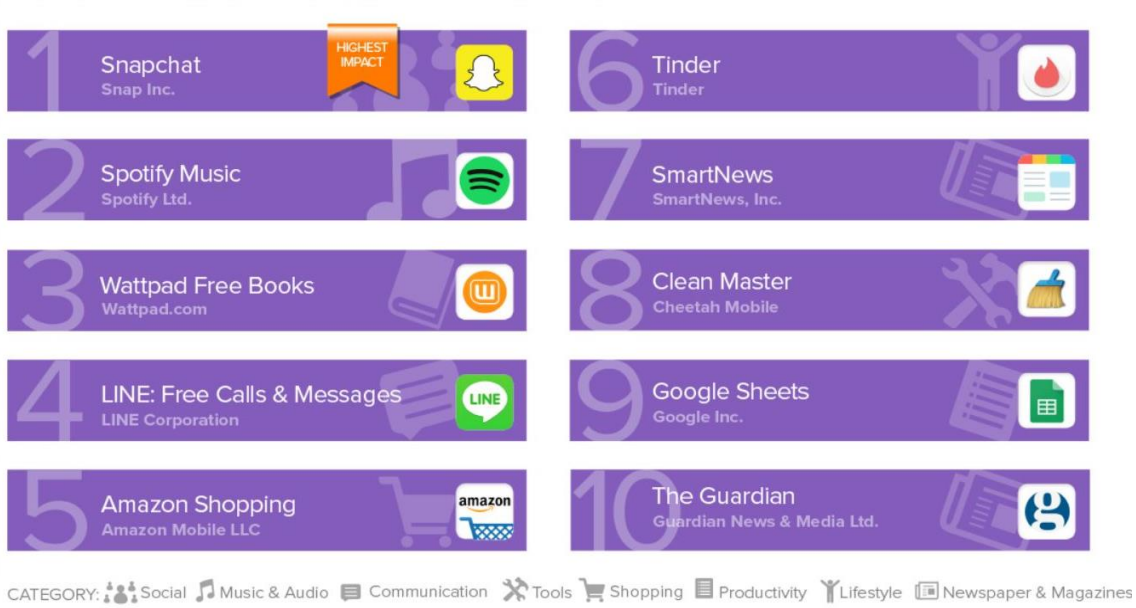

FIGURE 3. Top 10 most performance draining Android applications (AVAST, Villinger 2016, cited 25.10.2017)

3 METHODS FOR IMPROVING BATTERY MANAGEMENT OF THE SMARTPHONE

Modern smartphones are technologically very advanced but do not have an endless battery duration. Advancements in various technological fields such as 4G / LTE networks, mobile applications and GPS radios have resulted in an increasing amount of burden to battery endurance. Therefore, smartphone users are seeking various ways for increasing battery lifetime. (Lendino, 2014, cited 11.10.2017).

As Figure 4 shows, smartphones can have multiple different settings that can assist with managing battery consumption. At first, learning how to use a large amount of functions can be seen as an overwhelming task. Therefore, there can be confusion among users how to use those specific features and which of them help with increasing battery lifetime. (Peltonen, Lagerspetz, Nurmi, Tarkoma 2016, 6).

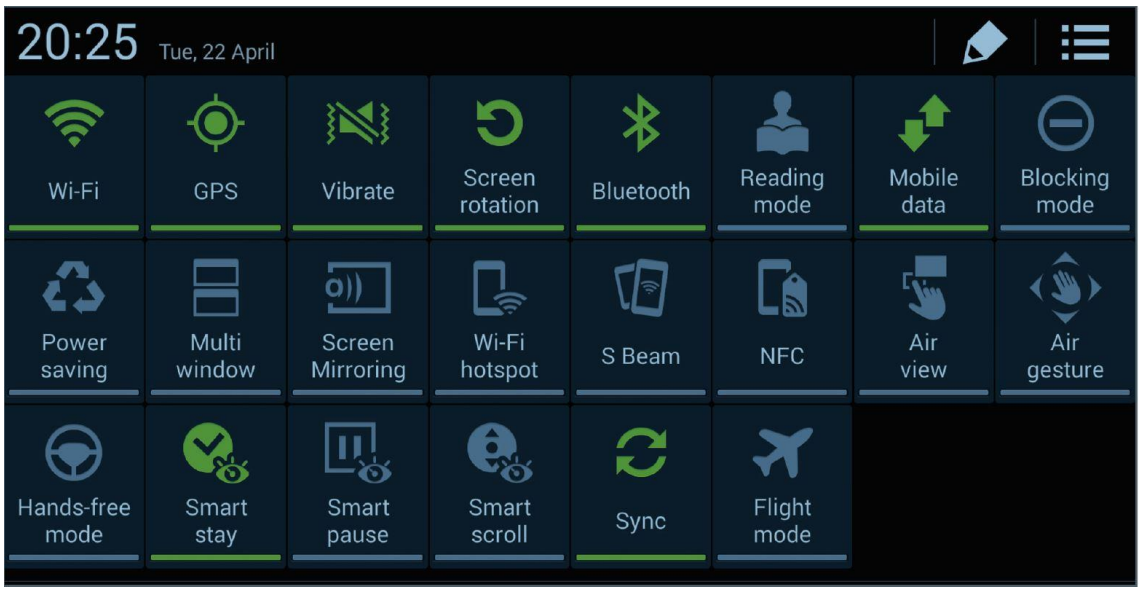

FIGURE 4. An overwhelming amount of system settings on modern smartphones: Samsung Galaxy S4 (Peltonen, Lagerspetz, Nurmi, Tarkoma: Where Has My Battery Gone, 2016)

In the past few years, there has been a notable improvement in smartphone display technology and processing power. On the other hand, there has not been a great improvement in battery technology. Nowadays smartphones have large displays, complex sensors and faster application

processors that drain the battery swiftly. However, there are some ways that can help with increasing battery lifetime. (Arora 2017, cited 11.10.2017).

3.1 Airplane mode

Modern smartphones constantly use energy by receiving and transmitting signals to the nearest mobile cell phone towers and searching the exact location of the phone with the assisted GPS application, resulting in draining the battery quickly. (Ahaskar 2015; Kiger 2017, cited 13.10.2017). Smartphones have a setting called Airplane mode, also known as Flight mode. Airplane mode disables Bluetooth, cellular network connections, Wi-Fi and mobile data connections, thus preventing the disturbance of various sensors and other electronical equipment during the flight. Therefore, when the smartphone is not being used, Airplane mode can be a great tool for increasing battery lifetime. Although Airplane mode is designed to disable several functions of the smartphone, during the Airplane mode it is still possible to use some applications, such as camera, playing mobile games and multimedia streaming applications. (Hill 2017, cited 13.10.2017).

Graziano (2014), conducted a study that examined if Airplane mode affects the charging time of the battery when charging from 1% to full battery with his LG Nexus 5 smartphone. In the study it was found out that as Airplane mode disables all wireless radio frequencies, it helps recharging the battery of the phone slightly faster. Enabling Airplane mode while charging resulted in four minutes faster charging time. Given the minor difference between using Airplane mode during charging or not, it is debatable whether it is useful to disable various communication networks for acquiring a superficial benefit in battery charging time. (Graziano 2014, cited 13.10.2017).

3.2 Screen brightness configuration

Research in battery management has shown that adjusting screen brightness has a major impact on the battery duration of the smartphone. Higher screen resolution and the level of brightness often results in more load on the smartphone, draining the battery faster. Using automatic screen brightness adjustment can increase the battery lifetime significantly. (Peltonen et al. 2016, 8; Ahaskar 2015, cited 13.10.2017).

According to a study by Shye et al. (2010) analyzing smartphone usage characteristics, it was discovered that the screen of the smartphone uses a considerable amount of energy. In fact, it was found out that screen uses the most amount of energy of the hardware components of the smartphone. Therefore, it is critical to adjust screen brightness settings for increasing the lifetime of the battery. (Shye et al. 2010, 376).

3.3 GPS & Location sharing management

As there have been multiple advancements in smartphone technology, the need for acquiring the exact location of the user or the device has become more important in the past few years. Smartphone users are currently using various mobile applications that both search for the precise location and share the information with other users or services. One of the most popular location finding technique is the Global Positioning System (GPS), which is widely used in various mobile applications implementing satellite location tracking. (Chun, Lee, Nah, Choi, Park 2011, 121).

It has been found out that when the GPS is on, the mobile operating system cannot use a so-called 'sleep state'. Smartphones gain their battery life mostly because of the adjustments in enabling and disabling the energy-saving 'sleep states.' Although an efficiently designed mobile application can make a notable difference in GPS usage, keeping GPS on drains the battery swiftly. (Love, 2013, cited 14.10.2017). Nowadays location sharing is a popular universal trend. Mobile applications such as Google Maps and various outdoor exercise applications like Sports Tracker use GPS, Wi-Fi and cellular networks for finding user's precise location. (Ahaskar 2015, cited 14.10.2017).

3.4 Battery saving mode

Newer smartphones have pre-installed battery-saving mode that can help with adjusting multiple power-draining features and applications. These include for example dimming the screen, modifying screen fading timer settings and disabling automatic application updating in the background. (Strohmeyer 2011, cited 14.10.2017). Normally, battery saving mode activates when smartphone's battery level drops below 20%, but it is advisable to adjust battery saving mode to be activated at 30%. This results in longer battery lifetime as the battery saving mode is active for a longer time. (Martin 2016, cited 14.10.2017).

Along with a battery saving mode, various smartphones can also have an additional ultra-saving mode. Depending on the manufacturer, ultra-saving mode may disable internet connection, Wi-Fi, GPS, mobile data and other functions (Figure 5). However, when ultra-saving mode is active, it is still possible to make phone calls and send text messages. Ultra-saving mode is designed to save as much battery lifetime as possible, especially for emergency use. (Martin 2016, cited 14.10.2017).

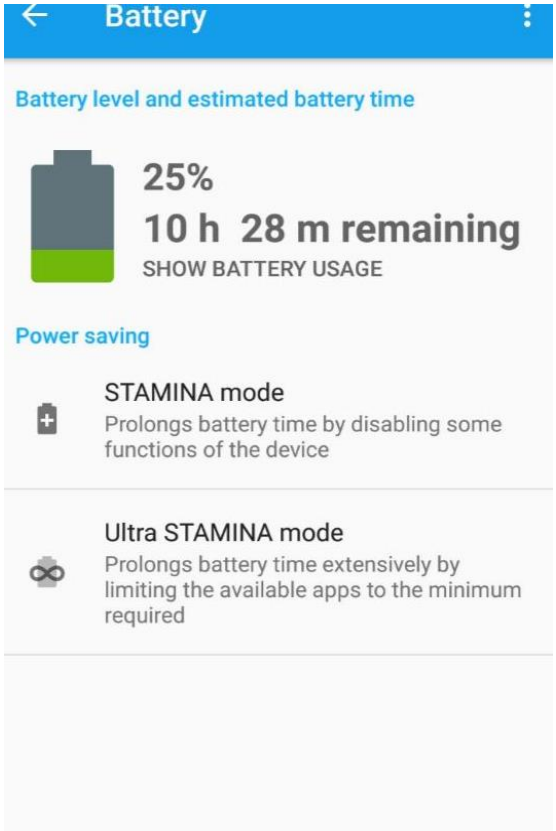

FIGURE 5. Pre-installed battery saving modes in Sony Xperia Z5, Android version 7.1.1

3.5 Battery charging management

Battery recharging times will depend on the health of the battery, its size and what kind of charger is being used. Since battery chargers have various power outputs, smartphone battery reloads faster with more powerful recharging devices. (Graziano 2014; Black 2015, cited 14.10.2017). As even up-to-date lithium-ion batteries are not everlasting, they degenerate over time after a fixed amount of full drain 'cycles'. Majority of smartphone producers claim their batteries to manage from 300 to 500 'cycles' before battery lifetime starts to decrease. (Titcomb 2017, cited 14.10.2017). After these certain amounts of 'cycles' smartphone batteries are not able to store as much electricity thus losing power and will result in shorter battery lifetime. (Jary 2017, cited 14.10.2017).

Modern smartphones have advanced systems that receive the power they need from charging. Therefore, leaving battery charging for a short time after it is full, may not necessarily be harmful for the battery. However, it is not advisable to leave battery charging for a longer time as overheating and high voltage stress can cause damage to lithium-ion battery quickly. (Titcomb 2017; Villas-Boas 2016, cited 14.10.2017). It has been recommended that lithium-ion battery should get a full recharge from 0% to 100% only once a month since constant full recharges have been noted to shorten battery endurance. (Jary 2017, cited 14.10.2017).

3.6 Battery management applications

Battery management applications claim to increase battery lifetime by shutting down various unnecessary applications and features that are running in the background. Some battery management applications prevent various applications from turning on automatically. However, these applications try to force start themselves over and over again. This may result in a never-ending cycle that can drain the battery even more rapidly. (Chandler 2012, cited 15.10.2017).

There is a lot of uncertainty of the usefulness of battery management applications. It is debatable if a battery management application saves the battery. It has been claimed that most well-known ways for battery saving like screen brightness adjustments are done manually. Additionally, it has been noted that some battery management applications do more harm than actually improve battery saving. (Hindy 2017, cited 15.10.2017).

3.7 Examples of battery management applications

AVG Cleaner

AVG states that AVG Cleaner Battery Saver and Optimizer mobile application identifies the main causes of battery drainage. As claimed by AVG, AVG Cleaner has ‘App Manager’ feature in the application, that overviews the overall performance of the smartphone. AVG Cleaner application is said to disable various battery-draining applications and help with configuring smartphone settings for increasing battery lifetime. (AVG, Villinger, 2017, cited 17.10.2017). Figure 6 shows the graphical user interface of AVG Cleaner-application. (AVG, Google Play, cited 17.10.2017).

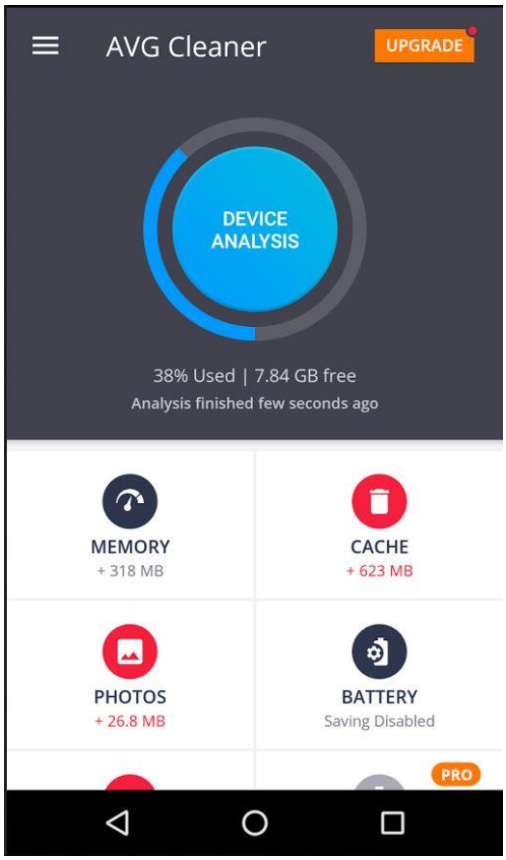

FIGURE 6. User interface of AVG Cleaner application (AVG, Google Play, cited 17.10.2017)

Battery Doctor

Battery Doctor by Cheetah Mobile states that it may provide a monitoring system for battery lifetime estimation and features that consume battery. Battery Doctor is said to have battery saving settings and tools that can increase the overall battery lifetime of the smartphone. It has also been stated that Battery Doctor closes unwanted running applications from background, which is said to increase the duration of the battery. (Cheetah Mobile 2017, cited 17.10.2017). Figure 7 shows the user interface of real-time Battery Condition monitor of Battery Doctor application. (Cheetah Mobile, Google Play, cited 17.10.2017).

FIGURE 7. Battery Condition monitor of Battery Doctor (Cheetah Mobile, Google Play, cited 17.10.2017)

360 Security

360 Security is an application by 360 Mobile Security Limited to Android operating system that claims to clear up junk files, application caches and increase the overall performance of the smartphone. 360 Security is said to protect the smartphone from various unwanted programs such as viruses and malware and enhance the battery life by closing unnecessary running applications. As seen in Figure 8, the Battery Saver feature of 360 Security application is stated to monitor battery overheating, mobile applications and processes that heavily consume the battery life of the smartphone and shut them down if needed. (360 Mobile Security Limited 2017, cited 4.11.2017).

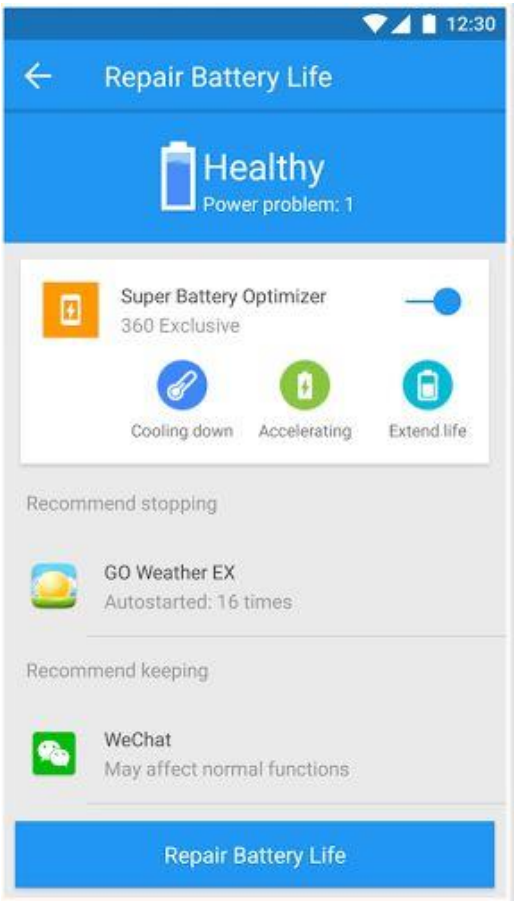

FIGURE 8. Interface of 360 Security's Battery life optimization (360 Mobile Security Limited, Google Play 2017, cited 4.11.2017)

4 RESEARCH METHODS

4.1 Survey of the energy efficient use of the smartphones

With the survey, the aim was to examine whether the respondents of the survey use their own smartphones energy efficiently. The respondents were from different degree programmes in the Oulu University of Applied Sciences, such as TIK (Tietojenkäsittely, Business Information Systems), BIT (Business Information Technology), DIB (International Business), exchange students and students from other degree programmes. The survey was conducted in English and consisted of twelve questions, of which three questions were free text choice questions and the rest either multiple choice or so called check box questions. The gathered statistical data of the survey was illustrated by direct screen captures from the conducted Webropol survey report and additionally from various Excel figures. The survey can be found as an attachment in Appendix 1.

The survey was conducted for the students of the Oulu University of Applied Sciences with an online survey provided by Webropol. A link to the survey for the respondents was given at the beginning of selected classes that were either compulsory or free-choice for students. In total there were 101 completed responses to the survey and 23 opened survey links which were not completed, which gave the survey a response rate of 81,45%. Figure 9 shows, that of 101 respondents, 65 (64,4%) were male and 36 (35,6%) female.

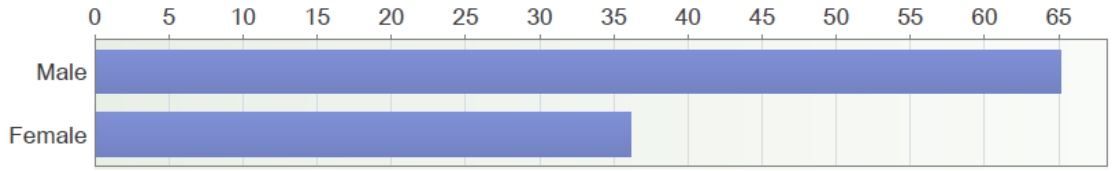

FIGURE 9. Genders of the respondents (n=101)

The distribution of age groups among respondents was following: 70 (69,3%) respondents were in the age group 18-23, 21 (20,8%) respondents in the age group 24-29, nine (8,9%) respondents in the age group 30-35 and one respondent (1%) was in the age group 36-40. Additionally, there were no respondents in the age group over 41. (Figure 10).

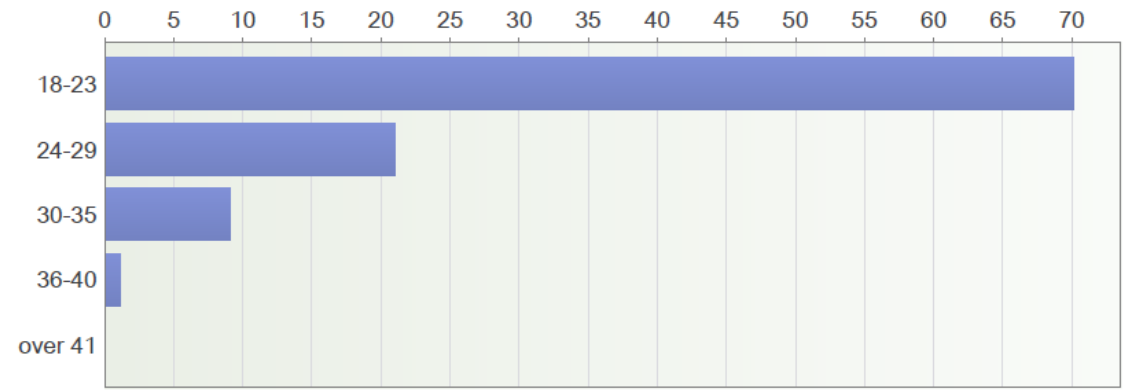

FIGURE 10. Age groups of the respondents (n=101)

The majority of the respondents, 52 (51,5%), were from TIK (Business Information Systems) degree programme, whereas 25 (24,8%) respondents were studying in BIT (Business Information Technology). 11 (10,9%) respondents were in DIB (International Business), seven (6,9%) were exchange students, and six (5,9%) of the respondents were in the group 'other' (Figure 11).

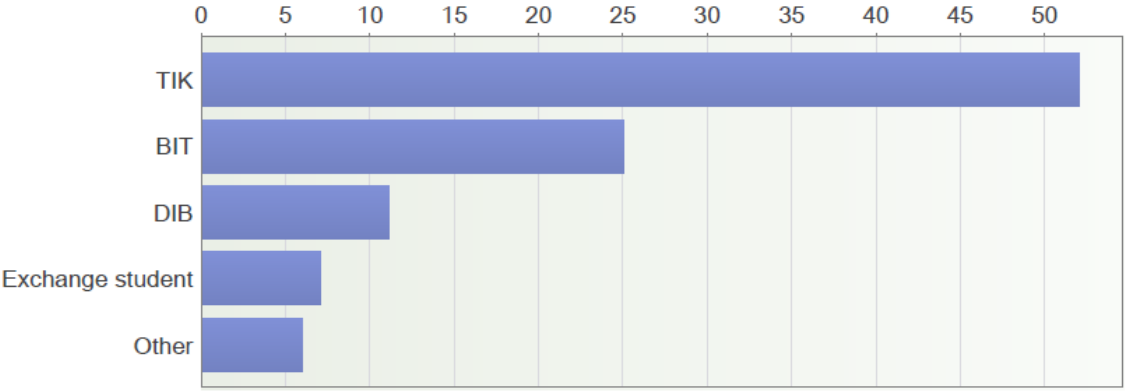

FIGURE 11. Degree programme (n=101)

4.2 Quantitative methodology

Quantitative methodology survey was chosen for acquiring as many respondents and diverse replies as possible. With the survey form, it is possible to collect information about facts, behavior, activity, knowledge, values, attitudes, beliefs, perceptions and opinions from the respondents. In addition, it is also possible to request estimations and arguments for activity, opinions or convictions. (Hirsjärvi, Remes, Sajavaara 2007, 192).

In the survey method information is gathered in standardized form from the group of individuals. Typically, a sample is taken from a group of individuals and material is collected by each individual in a structured form. Usually, it is done by using a form of survey or a structured interview. Based

on the collected material, the phenomenon can be described, compared and explained. (Hirsjärvi et al. 2007, 130).

Material that is gathered with the survey is usually processed with quantitative method. With the survey, it is possible to collect a vast amount of research material. The type of survey, also called as ‘an informed survey’, signifies that the researcher distributes the access to the survey form in person. In the informed survey the researcher may visit the respondents of the survey in schools or working places where the respondents are personally available. When visiting the respondents, the researcher may explain the purpose of the survey and answer to the possible questions of the respondents. (Hirsjärvi et al. 2007, 190-192).

5 RESULTS OF THE SURVEY

5.1 Features and applications of smartphone

When the respondents were asked in a multiple-choice question which smartphone operating system or systems they use, the majority of respondents, 78 (52,3%), used Android OS. Windows OS was the second most used operating system with 43 (28,9%) respondents (Figure 12). Apple iOS was the third most popular with 24 (16,1%) respondents. In the 'other' group, the respondents had the option of describing the alternative operating system if they were using one. In total there were four (2,7%) respondents in this section, in which all respondents told using Linux OS.

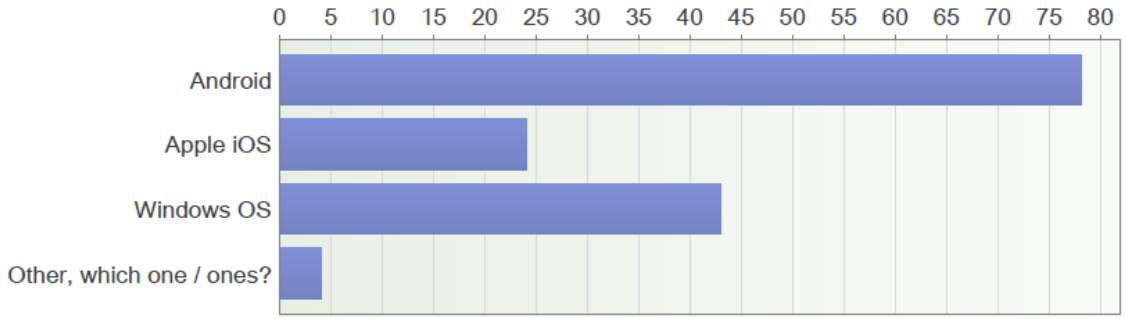

FIGURE 12. Smartphone operating system (n=149)

Duration of the smartphones battery

In the fifth question respondents were requested to estimate, how long on average they think that the battery of their mobile phone lasts. As Figure 13 shows, the most popular option was 'One day', with 44 (43,6%) respondents. The second most popular option was 'less than a day' with 32 (31,7%) respondents. 19 (18,8%) respondents selected the option 'Two days' and six (5,9%) respondents selected the option 'More than two days'. It was surprising to see that none of the respondents chose the last option, 'I don't know', which means that the respondents were well aware of their mobile phone's battery duration.

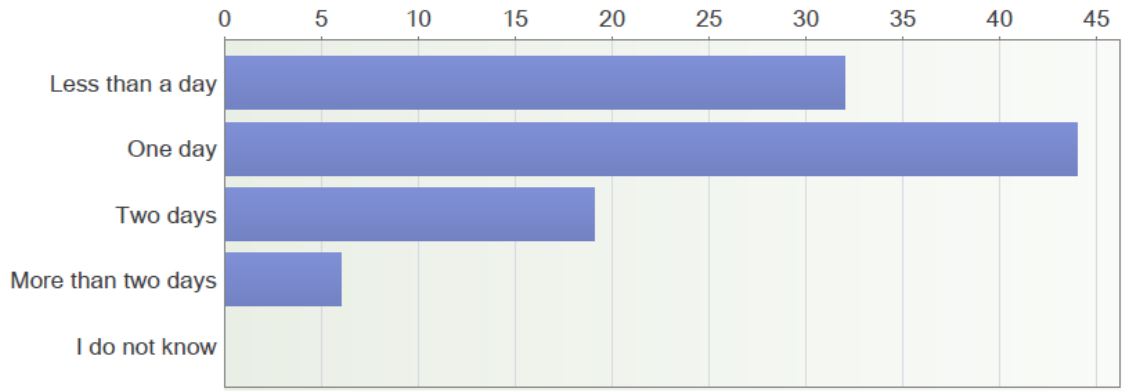

FIGURE 13. Duration of the smartphones battery (n=101)

Recharging the smartphone at a time

In the sixth question, the respondents answered the question how much on average they charge their smartphone at a time. As seen in Figure 14, 'overnight' was the most popular option with 45 (44,6%) respondents. The second most popular option was '1-3 hours' with 33 (32,7%) respondents whereas 21 (20,8%) respondents selected the option '4-6 hours'. Furthermore, two (1,9%) respondents selected the option 'more than 6 hours'. (Figure 14).

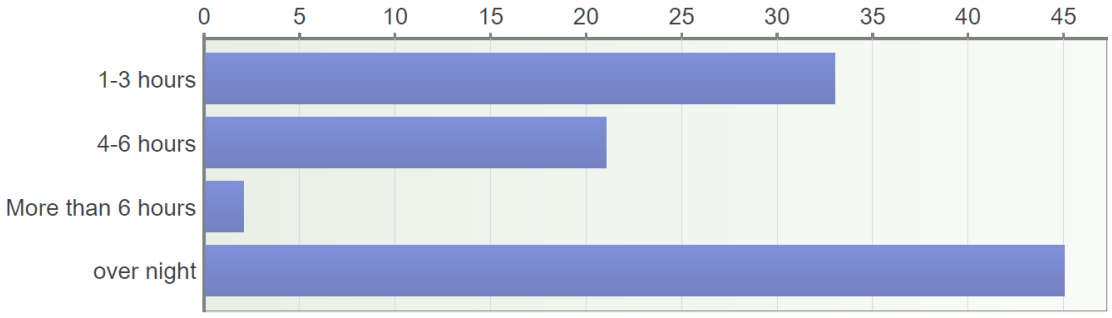

FIGURE 14. Recharging of the smartphone at a time (n=101)

Battery management applications

When asked of the usage of 'battery management applications', the respondents answered if they used one or more of popular applications that advertise themselves claiming to improve the battery duration management and energy efficiency of the smartphone. The question included a possibility to select multiple answers, which resulted in total of 106 replies. As seen in Figure 15, a clear majority, 71 (67,0%) of the respondents, did not use any 'battery management applications'. On the contrary, eight (7,5%) respondents used AVG Cleaner whereas six (5,7%) respondents used

360 Security - Antivirus Boost. Additionally, two (1,9%) respondents used McAfee and one (0,9%) respondent used Battery Doctor. However, 18 (17,0%) respondents chose the option 'Other', meaning applications that were not mentioned in the list. These answers include eight respondents that used their smartphones pre-installed own 'battery management' application and four respondents that used Avast Mobile Security. Furthermore two respondents used CM Booster-application, one respondent told using F-Secure Safe.

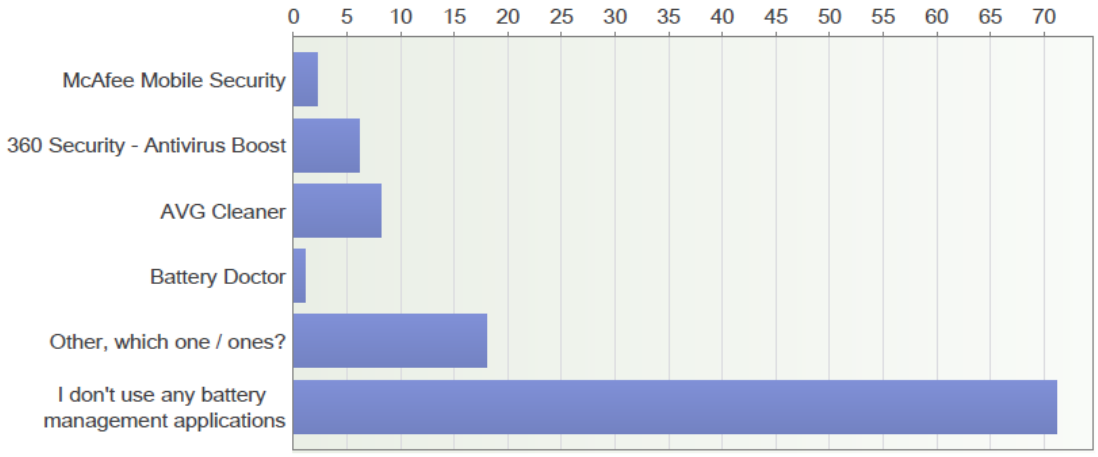

FIGURE 15. Usage of battery management applications (n=106)

In the follow-up question the respondents gave opinions and estimates for the usefulness of the 'battery management applications' if the respondents used them. The question was optional and resulted in total of 27 answers. As Figure 16 shows, there were many different opinions about the usefulness of battery management applications which ranged from respondents finding those not useful at all, the opinion that battery management applications are useful and lastly respondents that were neutral about the subject.

Majority of the respondents that answered this question, 12 (44,0%), found battery management applications useful. However, there were also concerns whether these applications, especially the free versions of them, generate extra pop-up advertisements of other applications and other unwanted notifications. Conversely, 10 (37,0%) respondents did not find battery management applications useful. Of these answers there were multiple opinions that criticized the usefulness of these applications and if they actually benefit from saving battery life at all. Some of these respondents told that they have been using battery management applications but did not see any improvement in battery saving of the smartphone.

There were also respondents which told that smartphone's own pre-installed battery management

application made any other similar applications unnecessary. Furthermore, five (19,0%) respondents that had a neutral opinion of them, meaning not being sure if they have a positive or a negative opinion about the battery management applications.

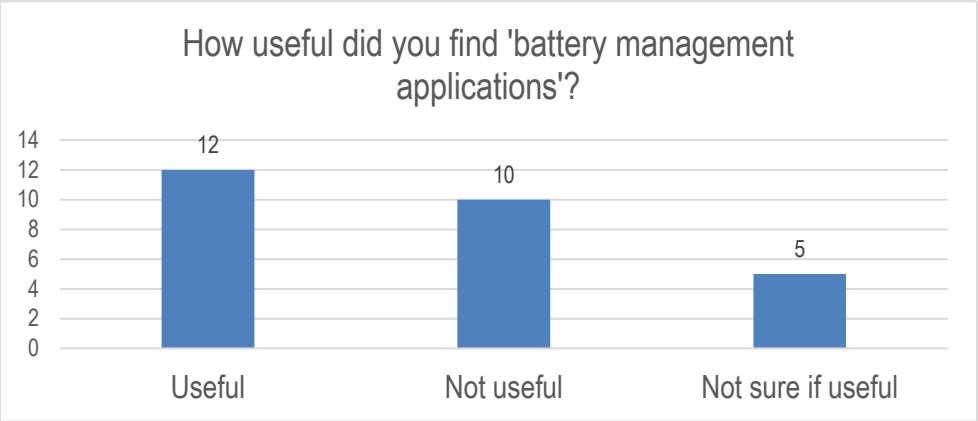

FIGURE 16. Usefulness of battery management applications (n=27)

5.2 Attitudes and knowledge towards sustainable use of the smartphone

As seen in Table 1, in the seventh question the respondents gave various statements regarding their knowledge and understanding about sustainable use of the smartphones. The scale of the statements was 1 = strongly disagree, 2= somewhat disagree, 3= neutral, 4= somewhat agree and 5= strongly agree. In general, the respondents were clearly well aware on average, which elements and applications are responsible for draining the battery life. Similarly, the respondents were also well aware of how to turn off applications that are consuming the battery life heavily. Furthermore, the respondents also knew how to improve battery saving and the sustainable use of their smartphone. Additionally, even though the majority of the respondents knew how to use smartphones energy efficiently, it was surprising to see that many of the respondents were not necessarily doing so, as seen in Table 1. Although many of the respondents did not study the quality of the phone batteries or compared the technical features of the battery before the purchase, the distribution of the answers was surprisingly even. Overall, the majority of the respondents knew how to use 'battery management applications' and identified energy saving and sustainable development issues either 'neutral' or somewhat important for them.

TABLE 1. Statements of understanding sustainable use of smartphones (n=101)

	1	2	3	4	5	Total	Average
I know which elements (GPS, Bluetooth etc.) are responsible for draining the battery life	2	4	9	30	56	101	4.33
I know which programs/ apps are draining the battery life	4	6	17	34	40	101	3.99
I know how to switch off some programs/ apps that are using a lot of battery	4	1	13	22	61	101	4.34
I know how to improve battery saving of my phone	0	7	18	41	35	101	4.03
I'm using mobile devices energy efficiently	9	32	35	18	7	101	2.82
I studied the quality and duration of the phone batteries before the purchase	21	24	22	17	17	101	2.85
The technical features of the battery affected to the decision of the purchase	22	20	22	21	16	101	2.89
I know how to use the 'Battery life Booster applications' that are closing unnecessary running programmes from my phone	15	18	18	24	26	101	3.28
Energy saving and sustainable development issues are important to me	10	11	30	31	19	101	3.38

Usage of the popular features and applications

Table 2 shows the usage of popular smartphone features and applications. This question was scaled from 1 to 3, with possible answers ranging from 1= not using at all, 2= only when needed and 3= it is always on. Majority, 52 (51,5%), of the respondents used the Bluetooth-feature only when needed. On the contrary 45 (44,6%) respondents were not using the feature at all (Table 2). 50 (49,5%) respondents used Wifi only when needed, in comparison to 41 (40,6%) respondents chose the option 'it's always on'. Whatsapp was always on with the majority, 64 (63,4%) respondents although conversely 29 (28,7%) used it only when needed. 45 (44,6%) respondents used Facebook only when needed, whereas 32 (31,7%) respondents identified with the option 'it's always on'. 44 (43,6%) respondents used other social media applications only when needed followed by 33 (32,7%) respondents that were not using other social media applications at all. Majority of the respondents, 68 (67,3%), used GPS-feature only when needed. Usage of the synchronized e-mail application was always on with the 63 (62,4%) respondents in contrast to 20 (19,8%) respondents that were not using them at all.

TABLE 2. Usage of features and popular applications of the smartphone (n=101)

	1	2	3	Total	Average
Bluetooth-connection	45	52	4	101	1.59
WiFi-connection	10	50	41	101	2.31
WhatsApp	8	29	64	101	2.55
Facebook	24	45	32	101	2.08
Other social media application (Tumblr, Twitter etc.)	33	44	24	101	1.91
GPS-navigation system	15	68	18	101	2.03
Synchronized e-mail application (you will immediately get an update when you got a new mail)	20	18	63	101	2.43

5.3 Free text answers

In the ninth question, the respondents were asked if they use any other applications that are always on which were not mentioned in the previous list. This resulted in 45 individual responses and 62 answers in total (Figure 17). The answers were divided into following groups: Instant messaging & social media applications, Music & video streaming applications, Mobile security & battery saving applications, Mobile games, Internet & new feed applications, Travel planning applications and 'Other', meaning the applications that are always on which did not belong to aforementioned groups. In this free text question, it was possible to list multiple applications.

Majority of the replies, 31 (50,0%) in total, belong to the group that has instant messaging or social media applications always on. This includes for example 10 replies with cloud-based instant messaging application Telegram. In addition, there were five replies to instant messaging tool Facebook Messenger. Moreover, photo-sharing social media application Instagram got five replies, whereas multimedia sharing application Snapchat got four replies. There was also a comment from a respondent that noticed when leaving Facebook Messenger running to background, the battery life drains quickly, possibly causing heating in the battery area of the smartphone.

Second most popular group among respondents was having music & video streaming applications always on with nine (14,5%) replies. These answers include for example three replies to video streaming application Youtube, whereas there were two replies to music streaming software

Spotify. Additionally, there was one reply for video and movie stream application Netflix, similarly with one reply for having gaming-related video streaming application Twitch always on.

As seen in Figure 17, there were five (8,0%) replies in the mobile security & battery saving group. There were two replies to Avast Mobile Security, similarly with two replies for an unnamed mobile security application. Additionally, there was one reply to having Avast Battery Saver always on.

Furthermore, there were five (8,0%) replies to internet browser & news feed applications. Mobile games, such as Pokémon GO, got three (5,0%) replies. Public transportation travel planning application Nysse got two (3,2%) replies. Moreover, there were seven (11,3%) replies to the group 'Other' that included several different applications, such as Fonecta Finder, Fitbit Activity, organizational communication tool Slack and project management application Trello.

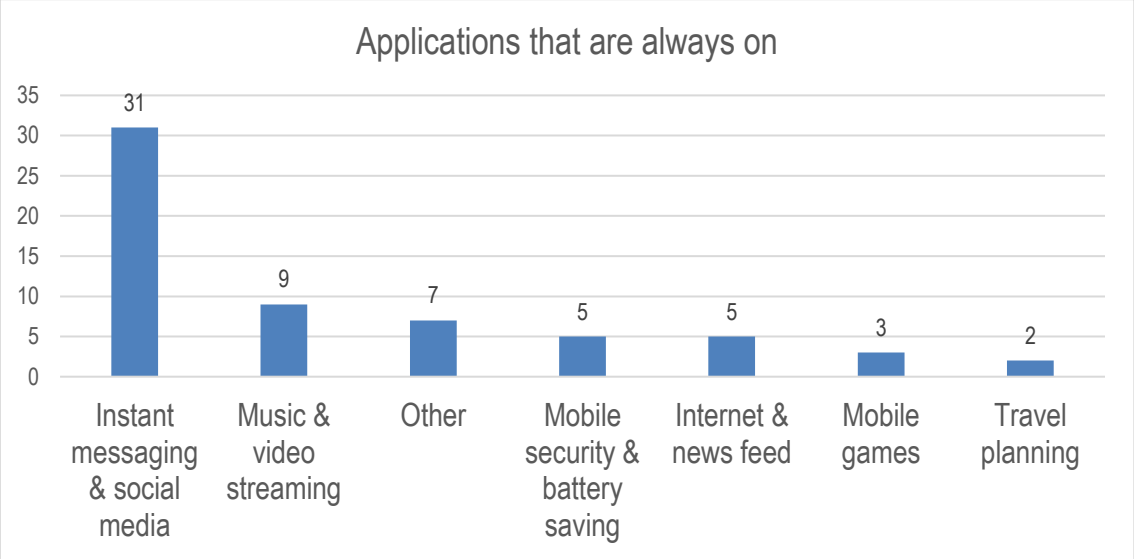

FIGURE 17. Applications that are always on (n=62)

Other methods of using smartphones in an energy efficient way

When the respondents were asked of any other methods of using their mobile phone in an energy efficient way, the question received 49 individual replies from respondents and 61 answers in total (Figure 18). The question included the possibility to answer either in Finnish or English and to list multiple answers on how to manage smartphone use in an energy efficient way. The replies of the question were divided into following groups: Screen brightness & screen sleep timer settings, Battery saving mode, Closing unnecessary running applications, Not using the phone all the time, Battery recharging management and Closing internet connection, Wi-Fi & GPS when not needed.

Most popular group among respondents was adjusting Screen brightness & screen sleep timer settings with 19 (31,1%) replies. These answers include screen brightness configuration with total of 15 replies and three replies that advised to put a timer for the screen to shut down after a certain amount of time. Additionally, there was one reply that suggested configuring the screen color code to #000, meaning adjusting the brightness so that the background color is completely black.

In addition, the group Battery saving mode received 16 (26,2%) replies. Of these replies there were 10 replies that advised using 'battery saving mode' always when possible. However, one respondent expressed concern whether the battery saving mode is affecting battery lifetime at all. Conversely, there was also one respondent that underlined the importance of battery saving mode as a key to a long-lasting battery lifetime. Six replies suggested keeping 'flight mode' activated when the smartphone is not being used. As flight mode disables many active functions of the smartphone, the lifetime of the battery increases significantly. (Hill 2017, cited 13.10.2017).

Closing unnecessary running applications received 11 (18,0%) replies. There were multiple advice on shutting down battery consuming applications, such as mobile games, internet browsers and other applications that could drain battery life quickly. Similarly, there were eight (13,1%) replies that advised keeping the smartphone on only when needed, thus preferring to keep it shut down when idle.

As seen in Figure 18, there were four (6,6%) replies in the group Battery recharging management. Two replies advised to remove the smartphone from charging when the battery has been charged full. There was also a mention that leaving the smartphone charging after it reaches 100 percent could damage the battery. One of these replies suggested recharging the smartphones battery only during the nighttime. On the contrary, there was also one reply that advised doing exactly opposite, avoiding recharging at nighttime. Furthermore, there were three (5,0%) replies that told to avoid keeping internet connection, Wi-Fi or GPS always on, since it will drain battery life quickly.

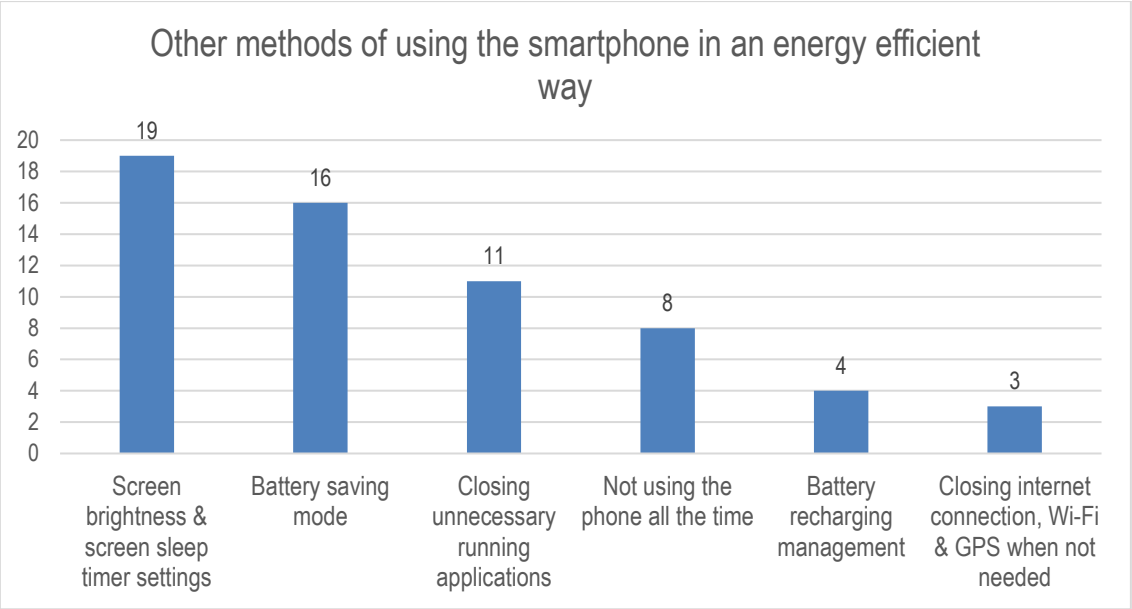

FIGURE 18. Other methods of using smartphone in an energy efficient way (n=61)

5.4 Comparison of replies between male and female respondents

When comparing the results of the survey between the answers of male and female respondents, there were some notable differences in the question 'How long do you normally recharge your phone at a time'. In total there were 65 male and 36 female respondents in the survey. As seen in Figure 19, the most popular option among female respondents was 1-3 hours with 17 (47,2%) respondents. Conversely, the same option was selected by 16 (24,6%) male respondents. Seven (19,4%) female and 14 (21,5%) male respondents selected the option 4-6 hours. In addition, one (2,8%) female and one (1,5%) male respondent chose the option more than 6 hours. The majority of male respondents, 34 (52,3%) told that they are charging their mobile phone overnight, whereas 11 (30,5%) female respondents chose this option. It can be seen that on average the male respondents tend to recharge their mobile phones for a longer time than female respondents.

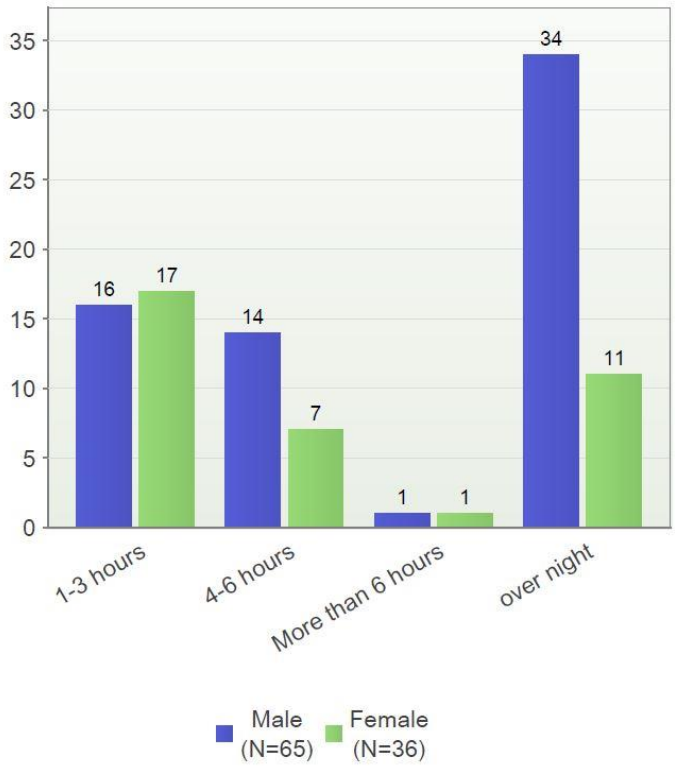

FIGURE 19. How long do you normally recharge your mobile phone at a time

Table 3 shows the comparisons of the statements between genders in the seventh question. The table presents the averages of both male and female respondents' replies to the statements. The scale of the statements was 1 = strongly disagree, 2= somewhat disagree, 3= neutral, 4= somewhat agree and 5= strongly agree.

Both male and female respondents had confidence in their own understanding about smartphone power consumption at a reasonably good level. Male respondents were more likely to believe in their own knowledge than female respondents. The statement 'I'm using mobile devices energy efficiently' received a reasonably low average among both male (2.91) and female (2.67) respondents. On average, male respondents believed more often that they use mobile devices more energy efficiently than female respondents. Both male and female respondents had almost equally studied quality and duration of the battery of the smartphone before purchasing. For female (3.22) respondents, the technical features of the battery affected the purchase decision more than male (2.71) respondents. On average, male respondents believed that they know how to use 'Battery life Booster' apps somewhat more often than female respondents. Furthermore, female (3.67) respondents considered energy saving and sustainable development issues to be much more important for them than to male (3.22) respondents.

TABLE 3. Comparison of averages in statements (question 7)

	Male (N=65)	Female (N=36)
I know which elements (GPS, Bluetooth etc.) are responsible for draining the battery life	4.37	4.25
I know which programs/ apps are draining the battery life	4.02	3.94
I know how to switch off some programs/ apps that are using a lot of battery	4.4	4.22
I know how to improve battery saving of my phone	4.14	3.83
I'm using mobile devices energy efficiently	2.91	2.67
I studied the quality and duration of the phone batteries before the purchase	2.85	2.86
The technical features of the battery affected to the decision of the purchase	2.71	3.22
I know how to use the 'Battery life Booster applications' that are closing unnecessary running programmes from my phone	3.35	3.14
Energy saving and sustainable development issues are important to me	3.22	3.67

In the ninth question, the respondents were asked to indicate how they used certain mobile applications. The scale of question was 1 = not using, 2 = only when needed, 3 = it's always on. Table 4 shows the comparisons of averages between male and female respondents. On average, both male and female respondents used Bluetooth connection and the GPS navigation system almost as often. However, female respondents used more often WiFi-connection and WhatsApp. Female respondents also used Facebook (2.31) and other social media applications (1.97) more often than male respondents. Furthermore, male respondents were slightly more likely to use a constantly synchronizing e-mail application than female respondents.

TABLE 4. Comparison of averages in statements (question 8)

	Male (N=65)	Female (N=36)
Bluetooth-connection	1.58	1.61
WiFi-connection	2.2	2.5
WhatsApp	2.52	2.61
Facebook	1.95	2.31
Other social media application (Tumblr, Twitter etc.)	1.88	1.97
GPS-navigation system	2.03	2.03
Synchronized e-mail application (you will immediately get an update when you got a new mail)	2.45	2.39

6 CONCLUSIONS

The purpose of the thesis was to investigate and to give some notable examples of the various ways of using a smartphone energy efficiently. For acquiring information about the smartphone user behavior, a Webropol survey was conducted to examine if the Oulu University of Applied Sciences students of the Business and Information Management have general information about energy efficient use of smartphones and whether they use smartphones in an energy efficient way. As nowadays almost everyone has a smartphone, it was presumed that the students of Business and Information Management had a fairly good knowledge of the topic.

In the theoretical part of the thesis multiple articles and studies were examined to gain a deeper insight of the subject. It was found out that smartphones have various features and functions that drain battery life, but the efficient power storage capacity of the battery is limited because of its weight and size. Therefore, many smartphone users try to increase the battery lifetime of their smartphone, for example by turning off energy-consuming functionalities. For achieving a longer battery lifetime, smartphone users may also reduce the usage of some features or popular interactive applications such as Twitter, Google maps or YouTube. Nowadays mobile applications consume a lot of battery life and a substantial part of the energy consumption of smartphones is related to the display, mobile data roaming and GPS-sensoring.

It was found out that there are multiple ways to decrease the battery consumption of the smartphone, such as using airplane mode, adjusting screen brightness and closing the GPS connection when it is not needed. Modern smartphones also have different pre-installed battery-saving modes that can help with managing energy consumption. The way a smartphone battery is charged affects profoundly the overall endurance of the battery. There are also numerous battery management applications which claim to increase battery lifetime of the smartphone. Although there is a lot of uncertainty of the usefulness of these applications, several battery management applications remain very popular among smartphone users.

Results of the survey showed that for the majority of the respondents the smartphone battery lasts for one day. Only for a small part of the respondents the battery lasts more than two days. It was also found out that the most popular way of charging the phone is overnight. A clear majority of the respondents did not use any battery management applications.

For the majority of the respondents that used battery management applications found these applications useful. Conversely, there was a considerable part of respondents who did not find battery management applications useful. Furthermore, there were concerns whether these applications also generate advertisements of other applications and unwanted notifications.
In general, the respondents were well aware of the elements and applications that drain the battery life of a smartphone and how to turn off these applications. Additionally, the respondents also knew how to improve battery saving and the sustainable use of their smartphone. Moreover, even though majority of the respondents knew how to use smartphones energy efficiently, it was surprising to see that many of the respondents were not necessarily doing so. The majority of the respondents knew how to use 'battery booster applications' and identified energy saving and sustainable development issues either 'neutral' or somewhat important for them.

It was found out that majority of respondents had instant messaging or social media applications always on. Furthermore, a substantial part of the respondents had music & video streaming applications always on. When the respondents were asked of methods of using their mobile phone in an energy efficient way, they pointed out adjusting screen brightness, using battery saving mode and closing unnecessary running applications.

There were some notable differences when comparing the results of the survey between the replies of male and female respondents. The results showed that on average the male respondents tend to recharge their smartphones for a longer time than female respondents. Both male and female respondents had confidence in their own understanding about smartphone power consumption at a reasonably good level. Male respondents were more likely to rely on their previous experiences than female respondents. Additionally, both male and female respondents had almost equally studied quality and duration of the smartphone battery before buying. For female respondents, the technical features of the battery affected the purchase decision more than to male respondents. Furthermore, female respondents considered energy saving and sustainable development issues to be much more important than to male respondents.

7 DISCUSSION

Throughout the study process I discovered that there are various factors affecting the duration of the battery lifetime of the smartphone. It was also useful to notice how profoundly one can affect the duration and endurance of battery lifetime with his or her own choices. After all, it depends on the user how energy efficient the usage of smartphone really is.

The student survey proved to be an efficient method for gathering essential information on the user behavior and the usage of the smartphones. In my opinion presenting the Webropol survey link at the beginning of mandatory and other classes was one of the most important reasons for achieving a relatively high response rate. If I had sent the survey link to students only by e-mail, the response rate could have been much lower. It was also surprising to see how many respondents answered the last free text questions. This indicates that there were probably not too many questions in the survey. As the respondents of the survey were students from the school of Business and Information Management, it was presumed that they had experience of using smartphones and solid overall knowledge of the subject.

Analyzing the results of the survey generated interesting findings. Even though the respondents claimed that they had good knowledge of how to use their smartphone energy efficiently, they were not necessarily doing so. It was also interesting to discover that there were some noteworthy differences between the genders of the respondents. For example, female respondents valued sustainable development and energy saving issues more than male respondents whereas male respondents had more confidence in their know-how in battery saving.

Even though at the moment the current smartphone battery technology is centered with lithium-ion batteries, in the near future we may see completely new technological changes in the industry. As the number of smartphones and smartphone users are rapidly increasing in the coming years, there are many interesting energy efficiency related topics to study in the future. Some of these possible studies could involve examining the energy efficient use of other mobile devices or how energy efficient the usage of modern advancements such as NFC technology is.

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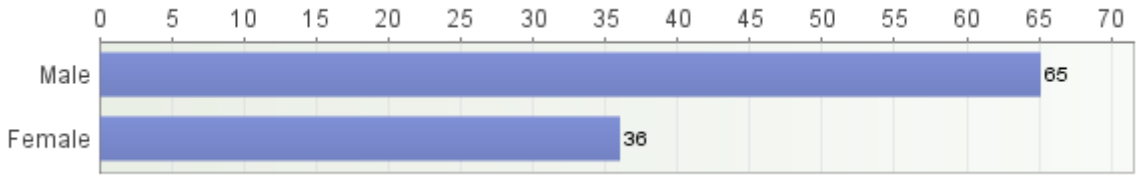
APPENDICES

APPENDIX 1

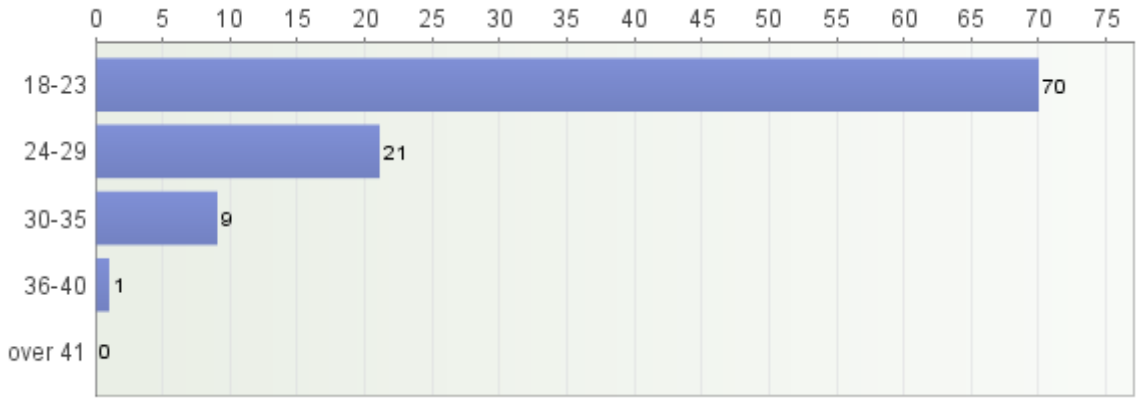
1. What is your gender?

Number of respondents: 101



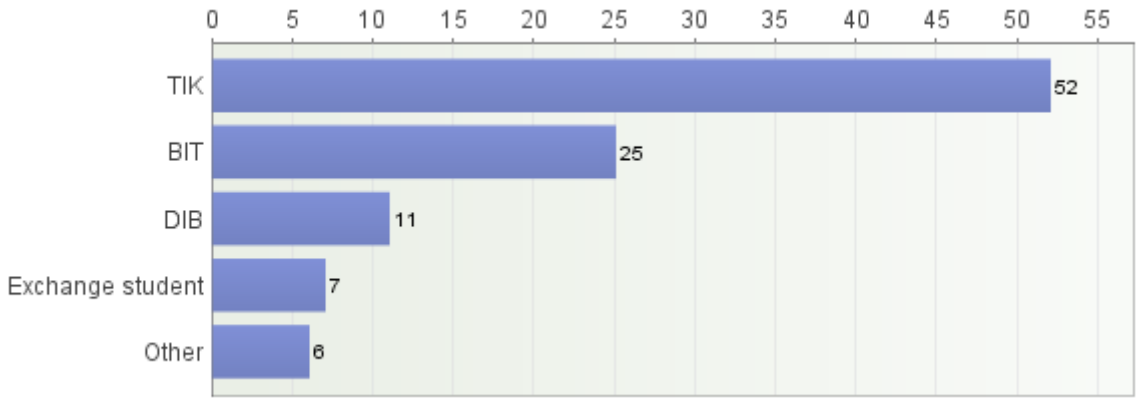
2. Which age group you belong to?

Number of respondents: 101



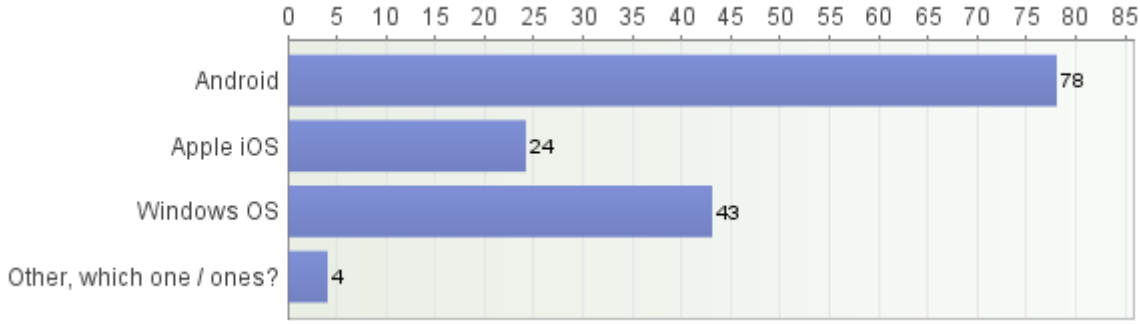
3. What is your degree programme?

Number of respondents: 101



4. What kind of operating systems are you usually using? (Multiple answers are possible)

Number of respondents: 101

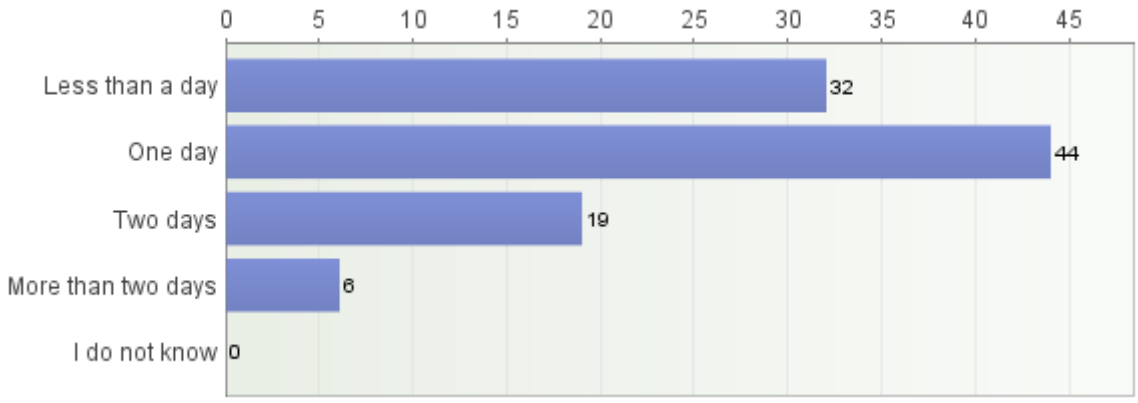


Open text answers: Other, which one / ones?

- linux
- Linux distros
- Linux
- Linux

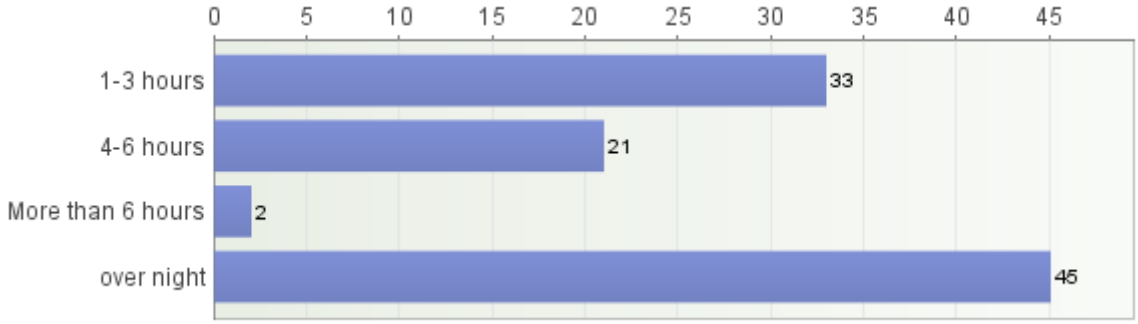
5. Estimate how long does your mobile phone's battery last?

Number of respondents: 101



6. How long do you normally recharge your mobile phone at a time ?

Number of respondents: 101



7. Please rate how strongly you agree or disagree with the following statements (1= strongly disagree, 2= somewhat disagree, 3= neutral, 4= somewhat agree, 5 = strongly agree)

Number of respondents: 101

	1	2	3	4	5	Total	Average
I know which elements (GPS, Bluetooth etc.) are responsible for draining the battery life	2	4	9	30	56	101	4.33
I know which programs/ apps are draining the battery life	4	6	17	34	40	101	3.99
I know how to switch off some programs/ apps that are using a lot of battery	4	1	13	22	61	101	4.34
I know how to improve battery saving of my phone	0	7	18	41	35	101	4.03
I'm using mobile devices energy efficiently	9	32	35	18	7	101	2.82
I studied the quality and duration of the phone batteries before the purchase	21	24	22	17	17	101	2.85
The technical features of the battery affected to the decision of the purchase	22	20	22	21	16	101	2.89
I know how to use the 'Battery life Booster applications' that are closing unnecessary running programmes from my phone	15	18	18	24	26	101	3.28
Energy saving and sustainable development issues are important to me	10	11	30	31	19	101	3.38
Total	87	123	184	238	277	909	3.54

8. Please rate how do you use the following programs / applications (1= not using, 2= only when needed, 3=it's always on)

Number of respondents: 101

	1	2	3	Total	Average
Bluetooth-connection	45	52	4	101	1.59
WiFi-connection	10	50	41	101	2.31
WhatsApp	8	29	64	101	2.55
Facebook	24	45	32	101	2.08
Other social media application (Tumblr, Twitter etc.)	33	44	24	101	1.91
GPS-navigation system	15	68	18	101	2.03
Synchronized e-mail application (you will immediately get an update when you got a new mail)	20	18	63	101	2.43
Total	155	306	246	707	2.13

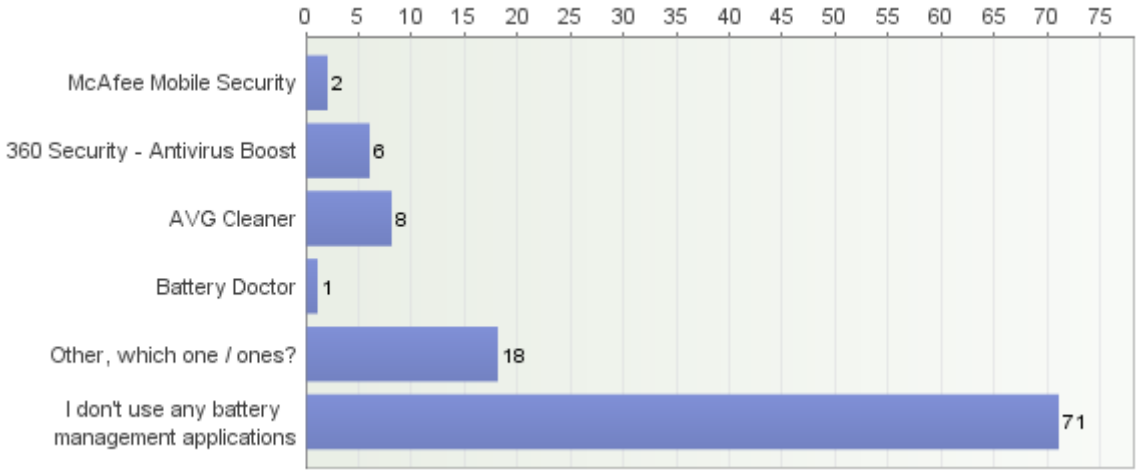
9. Are you using any other programs / applications than in the previous question, which are always on?

Number of respondents: 45

- Application which filters bluelight is always on. Always-On display.
- I play pokemon go 24/7. This is why I never have full battery, and don't have time to ever recharge it to max.
- Avast mobile security
- Mobile security apps.
- telegram
- Telegram
- Tinder
- instagram, telegram
- no
- If Facebook messenger has forgotten on, it will drain my battery in couple hours and my phone is hot. So usually I shutdown all running apps right before closing the screen.
- Fonecta caller
- Telegram
- Telegram and Discord
- JODEL=pane sitä, heitä se merikoskeen
- no
- alarm
- viber and some mobile games
- you tube
- NA
- At the moment, I am using cellular internet connection on my phone, so it it on almost all the time. Before, I had wired connection in my apartment, so I only used Wi-Fi on my phone.
- Fitbit activity bracelet app
- Facebook Messenger
- Antivirus is always on.
- Avast Battery Saver
  Avast Mobile Security
  Spotify
- No
- Telegram
- Messenger usually runs on background
- ResQ Club app, instagram, snapchat
- Youtube alerts, twitch alerts
- Telegram
- Snapchat
- Nysse - Journey Planner
  Spotify
- telegram
- No.
- redtube
- 4G, snapchat
- Discord and Telgram
- no
- podcast
- not always but instagram jodel and tinder
- No
- Instagram, Telegram, Snapchat, Netflix, YouTube, Games
- Kyllä, esimerkiksi Nysse-linja-autohakusovellus ja eri uutissivustot, kuten Iltasanomat ja Yle-sovellukset.
- Instagram and Facebook Messenger application
- Slack, Trello for work; Web browser because of certain important bookmarks; Messenger for conversation, ...

10. Are you using any of the following 'Battery management applications'?

Number of respondents: 101



Open text answers: Other, which one / ones?

- The phone's own programme cleaner.
- Battery saving feature on my iphone, also it shows which apps use the most batterylife in more specific details
- Avast battery saver
- CM Battery Booster Application
- Akku
- pre installed from samsung
- Avast Battery Saver
- CM
- The phone's own one and avast
- Samsung's own
- Huawei's own battery/memory application
- Avast Battery Saver
- Battery life Booster -kind off app
- Android default cleaner software
- Whatever is installed in Samsung Galaxy
- F Secure Safe
- The default one in my mobile operating system

11. If you have been using previously mentioned 'Battery management applications', how useful did you find those? (You can answer in Finnish or in English)

Number of respondents: 30

- Very useful
- En näe mitään eroa onko minulla Avast Battery Saver päällä vai ei.
- My phone battery is rather dead so I am unsure if there is really any difference.
- Not really helpful. I didn't notice any improvement.
- You can find most of those options within the phones settings itself(when you know where to look for), so I don't see it necessary to download another app.
- I find them really usefull. It really makes my battery life longer and keeps unnecessary programs off.
- everything mentioned above is garbage, greenify with root was ok.
- Not so helpful, more battery consumming

- its satisfactory
- not been using any
- The application is quite useful as it helps to detect programs that have been left running in the background by accident and automatically detects newly installed apps and automatically sets battery settings for them based on your preferences.

  However, it does create some extra junk notifications which can be relatively annoying.
- not very much often buggy and anoying
- I have used them way before (In Android 2.X days) but I didn't find them that usable.
- -
- I think 360 security is useful but actually i don´t use it for this pupose. I mostly use it for security.
- Pretty useful, in combination with the "energy saving" mode of my phone it significantly improved the battery life.
- It helps me to turn toff all my applications running at the background of my phone.
- They are good memory cleaners and all applications will shutdown after use. So no complaining.
- Kokeilin joskus appia mutta en kokenut hyödylliseksi
- Not as useful as I thought, basically no impact on the battery life.
- En tiedä, mutta puhelin muistuttaa niistä viikoittain automaattisesti.
- Not very useful.
- Ihan ok tarpeellisia, jos niitä muistaisi joskus käyttää. :D
- En ole varma, säästääkö sovellus todella akkua.
- I don't find the app that usefull, because it's just one button that shows how many procent you are currently using of your battery and then you can click it to opitimize your phone. I like to close the apps manually (I can check if I have something important open that needs saving etc) and I have made a routine of closing the un-used apps so that's comes kinda naturally.
- Software I use requires only one click to clean the device, so I use it always when I stop using the phone. It's fast & easy, and keeps the phone working.
- I get 15 min to 1 hour more time to use my phone so I find it useful.
- for me it is very useful and I can see the difference in lasting of battery
- -
- Useful of course, it allows me to use the phone in longer time without recharging. Recharge your phone a lot might damage the battery itself. So this is a way to restrain that situation a little bit.

12. Do you have any other ways to use your mobile phone in an energy efficient way? (You can answer in Finnish or in English)

Number of respondents: 49

- don't use it lmao
- I try to close all the apps I am not using at the moment and I use low battery state whenever my battery is under 30% so that I don't have to charge it all the time.
- Not use your phone all the time. Turn brightness to auto so at different locations you can use less light which might mean less battery consumption. Turn WiFi on only when needed. Close applications once you are done with them.
- Sometimes when I really need to save up some batterylife and can't recharge it, I put it on airplane mode. Then I can't really do anything with it but works well if I need to save up battery for taking photos etc.
- Using energy saving options and sometimes turning the phone to flight-mode or even turning it off, when I am not waiting for any important calls or messages to save battery for the times I need it.
- turning on phone's own energy saving features
- virransäästötila päällä
- Dimming the screen.
- Näytön kirkkauden asetukset.
- Managing screen brightness as it seems to be the main case of draining the battery quickly.
- I cannot think of any.
- amoled screen with #000 backgrounds everywhere possible, lightweight roms.
- I use battery saver option I phone settings when going long without the need for phone. Also when charging. Airplane Mode has also saved me a lot of power during trips.
- No
- by switching it off completely

- no
- less brightness
- none that i know of
- turn on battery saver mode
- I always keep my phone brightness on its lowest setting, unless it is otherwise needed. Furthermore, I always have a set screen off time and a set sleep time depending on the length of device inactivity.
- Use "hard" applications less and do not have Wi-Fi or cellular connection always on, I guess.
- Dim the screen and don't download useless apps.
- Limited use of web browsers
- Use the option of economy of the battery, decrease the brightness of the screen, change the time when screen turns itself off.
- not using it too much
  not use wifi
  keep it on flight mode
- Use when needed (don't use otherwise), use built-in battery saving options
- Yes, I´m using a Samsung Galaxy S5 which has an implemented battery saving mode. This mode is constantly turned on and reduces unnecessary functions and elements.
- The only is to turn it off but that's not possible.
- Lataat aina öisin
- Lower screen brightness, efficient settings.
- Pidän puhelimen lepo/nukkumistilassa suurimman osan päivästä.
- Kännykässäni on oma virransäästötila ja alhaisen akun tila, joita käytän satunniasesti. En ole kuitenkaan huomannut selkeää muutosta akun kulumiseen niitä käyttäessä.
- Puhelimen näytön kirkkaus mahdollisimman pienellä
- taustalla käynnissä olevien sovellusten sammutus käytön jälkeen.
- Taustavalo himmeänä mennään.
- Screen brightness
- Screen always on the lowest brightness.
- I put my mobile phone to airplane mode at night.
- Only use your phone for the important stuff, such as calling and communicating with people. Not playing games.
- I have the power saving mode enabled at all times, which I believe is the key for my phone's battery's long lifetime in-between charging.
- An application that turns down the screen brightness.
- Otan puhelimen irti latauksesta heti kun huomaan akun olevan 100% ja yritän välttää yöksi lataukseen jättämistä
- At nights and in dark places I use an app that dim the screen evenmore than factory apps.
- No
- -
- In my phone settings i have found a battery saving settings, which i use to save energy in my phone. I switch off some applications usually and sometimes use an option that swithces off all other applications and features but not calling and basic messaging. It is handy, when there is no possibilities to recharge the phone (e.g. outdoors).
- turn off un-necessary aplication when not needed like wi-fi, bluetooth, gps and sometime to save battery i use flight mode.
- I close all apps before going to sleep
- Always close unnecessary apps when not needed. There apps or certain features that keep on running in the background without user's awareness so there are certain apps that can be used to fix that.

  Never overcharge your phone because it will damage the battery

  I only know some I guess