**Faculty of Cognitive Sciences and Human Development**

# DESIGN AND DEVELOPMENT OF A CARBON FOOTPRINT MOBILE

# APPLICATION FOR UNIVERSITY STUDENTS

**Yee Chee Ling**

**Bachelor of Science with Honours (Cognitive Science)**

**2020**

**UNIVERSITI MALAYSIA SARAWAK**

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Masters                      ☐

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This declaration is made on the 7 day of AUGUST year 2020.

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**DESIGN AND DEVELOPMENT OF A CARBON FOOTPRINT MOBILE APPLICATION FOR UNIVERSITY STUDENTS**

YEE CHEE LING

This project is submitted
in partial fulfilment of the requirements for a
Bachelor of Science with Honours
(Cognitive Science)

Faculty of Cognitive Sciences and Human Development
UNIVERSITI MALAYSIA SARAWAK
(2020)

The project entitled 'Design and development of a carbon footprint mobile application for university students' was prepared by Yee Chee Ling and submitted to the Faculty of Cognitive Sciences and Human Development in partial fulfillment of the requirements for a Bachelor of Science with Honours  (Cognitive Science)

Received for examination by:

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7th AUGUST 2020

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# ACKNOWLEDGMENTS

# TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

# ABSTRACT

Global warming is a reality and it evolves into a whole bunch of issues, therefore, the focus research has become on the ways to reduce carbon emission effectively. Carbon footprint is the carbon dioxide emissions that are caused by a person's daily activities that could contribute to global warming. University students nowadays have strong knowledge and attitudes toward carbon footprint but they less practice it in their daily life. Thus, this research conducted to increase their awareness toward carbon footprint by developing a mobile application. The mobile application can calculate users' carbon footprint from a transportation aspect. The simple interaction design model is used to develop this mobile application which including identifying needs and establishing requirements, developing alternatives designs, building interaction versions of the designs and evaluating designs. After completing the design mobile application, an evaluation is conducted on the mobile application by conducting cooperative evaluation among five respondents who are university students aged between 20 to 25 years old. Usability testing is also used to evaluate the usability of the mobile application by the same respondents after the interactive mobile application prototype is done. Out of five respondents, three of them satisfied with the design of the mobile application and the other two respondents were unsatisfied with the design of the mobile application.

*Keyword:* carbon footprint, mobile application, usability

# ABSTRAK

Pemanasan global adalah satu kenyataan dan phenomena ini megakibatkan pelbagai masalah, oleh itu, cara untuk mengurangkan pelepasan karbon dioksida dengan berkesan menjadi fokus penyelidikan. Jejak karbon adalah pelepasan karbon dioksida yang disebabkan oleh aktiviti harian. Pelepasan karbon dioksida tersebut mampu menjadi salah satu faktor berlakunya pemanasan global. Kini, pelajar universiti mempunyai pengetahuan yang banyak tentang jejak karbon. Namun begitu, mereka kurang mempraktikkannya dalam kehidupan seharian. Oleh sebab itu, penyelidikan ini dijalankan untuk meningkatkan kesedaran mereka terhadap jejak karbon dengan mereka aplikasi mudah alih. Aplikasi mudah alih dapat mengira jejak karbon pengguna dari aspek pengangkutan. Model reka bentuk interaksi mudah digunakan untuk mereka aplikasi mudah alih ini yang merangkumi proses mengenal pasti keperluan dan menetapkan keperluan, mereka reka bentuk alternatif, membina versi interaksi reka bentuk dan menilai reka bentuk Setelah reka bentuk aplikasi mudah alih direka, penilaian terhadap aplikasi mudah dilakukan dengan mengguna cara penilaian koperatif. Lima orang pelajar universiti yang berusia 20 hingga 25 tahun dipilih sebagai responden untuk menjalankan penilaian ini. Ujian kebolehgunaan juga digunakan untuk menilai kebolehgunaan aplikasi mudah alih tersebut oleh lima orang responden yang sama setelah prototaip aplikasi mudah alih yang interaktif dilengkapkan. Dalam lima orang responden, tiga orang responden berpuas hati terhadap reka bentuk aplikasi mudah alih tersebut, manakala dua orang responden yang lain tidak berpuas hati terhadap reka bentuk aplikasi mudah alih tersebut.

*Kata kunci*: jejak karbon, aplikasi mudah alih, kebolehgunaan

# CHAPTER 1

# INTRODUCTION

**Background study**

**Mobile application**

Mobile technology is an extremely fast-growing sector that is closely tied to our work and daily lives (Jayatilleke, Ranawaka, Wijesekera, & Kumarasinha, 2018). The uses of mobile devices can be making phone calls, browsing the Internet, using utility applications etc. Mobile application which is also known as mobile app, is a software program that runs on mobile devices such as smartphones and tablet computers (Phongtraychack & Dolgaya, 2018). There are different categories of mobile applications such as gaming apps, business apps, educational apps, lifestyle apps, entertainment apps, utility apps and travel apps. Mobile application are important because almost 80% of people are currently online by using mobile devices. Most of these people prefer to use mobile applications, because they are easy to use and perform tasks instantly which one single tap will solve the tasks. Young people who are always using their mobile devices to search the World Wide Web as the world is at the fingertips (Phongtraychack & Dolgaya, 2018).

Furthermore, there are some mobile applications that give individuals various possibilities for evaluating the connections between actions and health, or for linking individuals and research. This kind of mobile applications that can connect consumption to impacts on biodiversity may provide a way for real-time consumer purchasing decisions to be updated and for sustainable consumption to be improved immediately (Nghiem & Carrasco, 2016).

**Carbon footprint**

Global warming is a reality and it evolves into a whole bunch of issues in politics, economy, culture, technology, climate and ecology from a single scientific question. Therefore, the focus research has become on the ways to reduce carbon emission effectively. The carbon footprint derives from the concept of ecological footprint, which is a calculation of human demand on the ecosystems on Earth. Carbon footprint is a measure of the total amount of carbon dioxide emissions directly and indirectly caused by an activity or accumulated over a product's life stages (Wiedmann & Minx, 2007). In other word, the carbon footprint is a calculation of carbon dioxide emissions. A personal carbon footprint is carbon dioxide emissions that are caused by a person's everyday clothes, food, housing and traffic (Gao, Liu, & Wang, 2014). Human-induced regional and global changes in the climate have resulted in ecological non-sustainability and health threats that require assessment of the global population health footprint. The data suggest that the larger footprints may impair health that gives rise to obesity, and in some low-income countries the effect is greater.

**Problem statement/ research problem and motivation**

A study has been done to evaluate the awareness level about carbon footprint among university students and the level of the carbon footprint they produced in Klang Valley. The result of the study showed that the students of higher education have strong knowledge and good attitudes toward carbon footprint but less practices towards reducing carbon footprint. The most common practice of students did was switching off the electrical appliances after using it which about 43.1% of respondents did . Nevertheless, 88.2% of the respondents have never checked their carbon footprint level (Syed Ismail, Ahmad, & Karuppiah, 2017).

Besides, conventional web-based carbon calculators or surveys, which involve working memory and manual input of personal habits, frequently lead to non-use, low adherence and thus inaccurate or incomplete data. Nevertheless, with the availability of smartphones, there is potential to use mobile apps to capture personal travel and calculate the carbon cost through new matrix computing methodology. Compared to conventional surveys or Global Positioning System (GPS) loggers, smartphones have advantages when collecting travel data as they are often taken with the user and have numerous built-in sensors such as GPS and accelerometers that enable automatic and continuous data collection, thereby providing a vast data source ("big data") for immediate data analysis, input, decision making (Sullivan et al., 2016). For example, such statistics can be used to determine the prevalence and period of motorized transport and active travel and thus estimate personal carbon emissions.

Furthermore, carbon footprint calculators are seen as important tools for reducing individuals' carbon emissions, but it has been reported declining popularity and trend over the past few years. As such, the usage of these tools needs to be improved, and promoting usage among end-users is becoming important for that. Therefore, improved usability is a known way of fostering device adoption (Bekaroo, Roopowa, & Bokhoree, 2019).

**General Objective and Research Questions**

To design and develop a mobile application of carbon footprint for university students

**Specific Objective**

- To study the knowledge of carbon footprint
- To design and develop a carbon footprint mobile application for university students

- To evaluate the carbon footprint mobile application for university students

**Research questions**

Based on the objective stated, several research questions can be obtained which is

1. What is the knowledge of carbon footprint and its content?
2. Is there any existing carbon footprint mobile application?
3. How to evaluate a carbon footprint mobile application?

**Definition of Term**

**Carbon footprint**

*Conceptual definition* = The carbon footprint is a measure of the exclusive cumulative amount of carbon dioxide emissions that is generated directly and indirectly by an operation or produced over a product's life stages (Wiedmann & Minx, 2007).

*Operational definition* = A carbon footprint is the amount of greenhouse gasses such as carbon dioxide that are produced by human activity and released into the atmosphere.

**Mobile application**

*Conceptual definition* = A mobile application is a software program that runs on mobile devices such as smartphones and tablet computers (Phongtraychack & Dolgaya, 2018).

*Operational definition* = Software that is installed in the phone.

**Usability**

*Conceptual definition* = Usability is usually seen as ensuring that interactive products are user-friendly, easy to understand, effective to use and enjoyable from user's perspective.

*Operational definition* = Quality attribute which assesses how easy it is to use the user interfaces

**Significance of the study**

The objective of this project is to design and develop a mobile application of carbon footprint for university students to help them to increase their awareness toward carbon footprint. The mobile application will provide a carbon footprint calculator for users to calculate their own carbon footprint. The evaluation of carbon footprint mobile application will be conducted at the end of design and development of this project. This project is significant to others factors such as:

1. Introduce and share the knowledge of carbon footprint to the university students
2. The results from this analysis for this mobile application can be used as guides for potential carbon footprint developers searching for a better approach for designing and developing carbon footprint based mobile applications.

**Scope of the study**

The scope of study for this project is to establish limits for what this project covers. The specifics of the scope of study are as follows:

1. *Subject* = this project is targeted to help them to increase their awareness toward carbon footprint
2. *Objective* = the objective is clearly stated which is to design and develop a mobile application of carbon footprint that can calculate the carbon footprint of university students from the transportation aspect

3. ***Timeframe*** = This project is expected to be done in a year.

4. ***Issues*** = the biggest issues in this project is the poor awareness on reducing carbon footprint

**Limitation of study**

There are several limitations in design and developing this project which is the mobile application is only to calculate users' carbon footprint based on their transportation aspect. This mobile application is also only in low-fidelity prototype form. The content in this mobile application is only provide carbon footprint calculator function.

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**CHAPTER TWO**

**LITERATURE REVIEW**

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**Carbon footprint and student**

  A study has been carried out to identify the energy consumption habits, behavioural patterns and intention of the students to participate in energy conservation at Tongji University, China. By combining with the usage data and emission calculations, the study showed that the average annual carbon footprint was a relatively modest 3.84 tons of carbon dioxide equivalent per student, with 65% contributed to daily life, 20 % contributed to transport and 15% contributed to academic activities such as studying. Figure 1 shows the percentage breakdowns for the total footprint and each of the three overarching categories. According to figure 1, dining was the main contributor to daily life, followed by showering and then dorm plug loads. Around half of the emissions in the transportation group is due to hometown travel, a third to regular commuting and the remaining fifth to holiday travel. In academics, computer use for study was the main contributor, followed by printing and scanning, and emissions correlated with the proportional contribution of students to energy usage in group study spaces were distantly followed (Li, Tan, & Rackes, 2015).
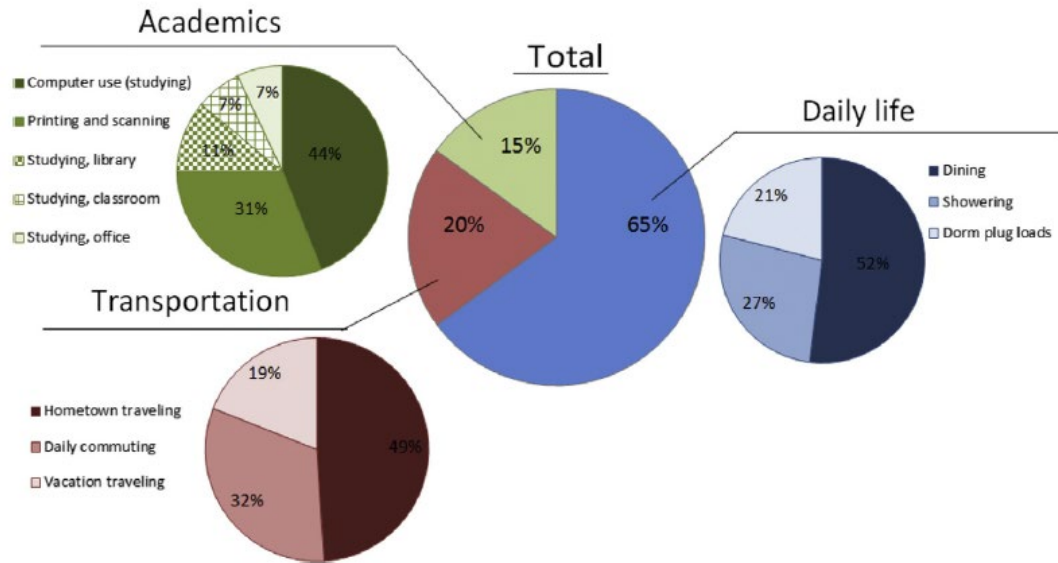
*Figure 1:* Carbon footprint of students from various types of activity such as the overall carbon footprint and the portions due to daily life, transportation and academics (Li et al., 2015).

Besides, another study has been carried out to measure the carbon footprint of 35 students in Environmental Science Program, Faculty of Science and Technology, Suan Sunandha Rajabhat University (SSRU) by using a web-based Thai carbon footprint calculator program of Thailand Greenhouse Gas Management Organization (TGO). The system was measured using electrical appliances on the basis of three factors which are transportation, food consumption and energy usage. Figure 2 showed the result of the study that major activities that generate carbon dioxide emission of environmental science were linked to electronics appliances which are 44% followed by 41% food consumption and 15% travel (Utaraskul, 2015).
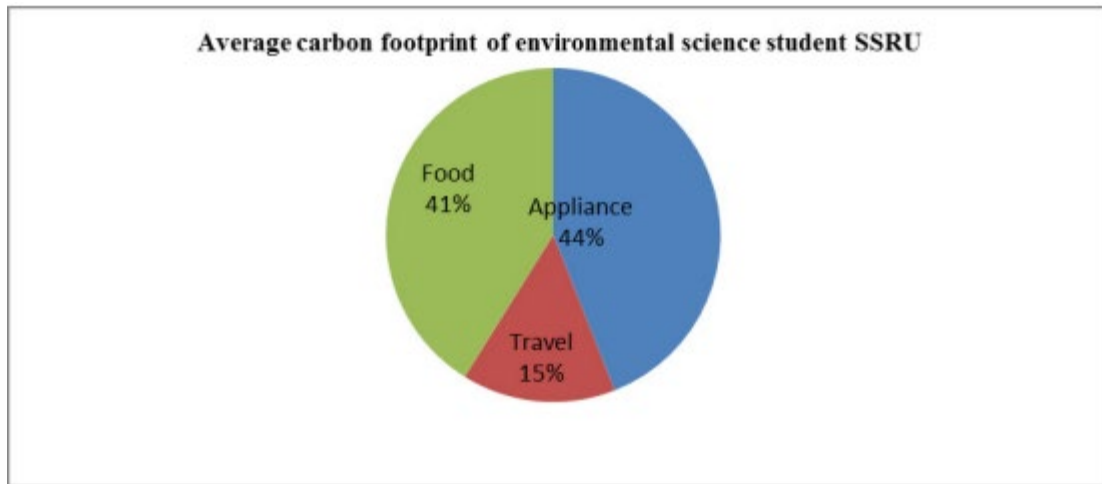
*Figure 2:* Average carbon footprint of environmental science student SSRU (Utaraskul, 2015)

**Carbon footprint that based on travel**

As motorization in Asia is as much a major carbon dioxide issue as it is a general transport and development concern, there is a study that focuses on delineating contributing factors leading to carbon footprint by those citizens directly or indirectly connected to the transportation activities of an educational campus institution. Carbon dioxide emissions due to the transportation activities being the main contributing activity leading to carbon footprint. Emissions are typically categorized into three tiers for calculation purposes , i.e., tier 1 for direct on-site fuel usage, tier 2 for energy purchase emissions in the form of electricity, heat, etc., and tier 3 for life cycle emissions not covered by tier 2. Some studies are measuring the carbon footprint up to tier 2, as the complexity and uncertainty rise beyond that. Nevertheless, the transport activities themselves can be further classified into two types, (1) direct activities for the campus transport purposes, and (2) indirect activities for the campus transport purposes. Tier 2 emissions are typically the maximum for an educational campus (Bhautmage, Tembhurkar, Sable, Sinha, & Adarsh, 2015).

**Carbon footprint calculation**

In 2014, there is a project highlighting the effectiveness of a motivation session to increase awareness of the carbon footprint that was generated by the travel behavior of the person. The individual carbon footprints were collected across two time frames (each time period is 7 days) and interspersed with a motivation session that was linked to knowledge about environmental awareness. Data of distances traveled was collected through the travel diary survey and included vehicle and fuel types. The distances estimated from each individual travel diary were converted into CO2 emissions by multiplying with a distanced-based emissions factor (Sukor & Basri, 2014). The equation to calculation to calculate carbon dioxide emissions of the study which based on the distance travelled method is showed as below:

$$CO_2 = \Sigma\, Distance_j \times d_j$$

$$d = b \times f$$

Where, $d$ = distance-based emission fiction factors (kg/100km)

$j$ = types of transportation

$b$ = litres per 100km (litres/100km)

$f$ = fuel-based emission factors (kg/ litres)

**Importance of having awareness toward carbon footprint**

A research was conducted to analyze the extent of public knowledge in Malaysia with respect to carbon dioxide emissions, climate change, carbon capture and storage (CCS). Public support is crucial to the success of carbon dioxide emissions reduction and carbon dioxide capture and storage (CCS) adoption and implementation. They need to be conscious and realize that CCS will reduce the amount of carbon dioxide pollution emitted into the environment significantly. Those with high knowledge are likely to be more environmentally conscious in order to lessen the effects of climate change. It is therefore necessary to educate and inform the general public across all media outlets (Ghazali, Zahid, Kee, & Yussoff Ibrahim, 2016).

**The importance of green application**

To boost environmental sustainability, information system work is attracting ever greater interest. In general, information and communication technologies (ICT) are a reasonable option for influencing people's actions. Information system has also proven effective in accomplishing sustainability-related goals, whether in the organizational context by promoting sustainable supply chain management practices and processes, promoting cleaner and resource efficient production, or promoting the transition to sustainable mobility alternatives such as electric mobility, by a novel technology driven innovative ecosystem. In recent years, a dedicated research field has emerged within the information system community that addresses environmental sustainability. The Green information system concept aims at using information systems (IS) to achieve and promote sustainability-related goals across different areas and domains, with a strong emphasis on the business sector (Brauer et al., 2016)**.**

In addition, the Google Play store review for apps addressing environmental sustainability concerns, provided numerous findings with a wide range of functionalities for different sustainability goals. However, the utilization rate of these solutions is very low, with 76% of the applications being downloaded and installed fewer than 5000 times on average, but with a rate of 4.0, the average rating of all apps identified is relatively high (with 5.0 as the highest). As the application's low installation numbers reveal, creating an app and uploading it to a distribution platform is not enough. In addition, the presence on the market of so many rarely used sustainability-oriented applications indicates a lack of coordination and information diffusion. Low software usage and the availability of different solutions for the same purpose create competition, thereby reducing the applications ' potential. A central platform as a unique moderator could increase the awareness and engagement by organizing the apps into one large group (Brauer et al., 2016)**.**

**Existing mobile application for carbon footprint**.

There are a few carbon footprint mobile applications that have been developed. In 2016, a carbon tracking platform, CarbonKit was developed to allow individuals to track and reduce their personal carbon emissions. CarbonKit is a platform that combines technology, markets and incentives for people empowering and rewarding people to reduce their carbon footprint. The goal-and-reward behavioural feedback loop has claimed that it is possible to combine with Big Data available from monitored behavioural, application and social media to make CarbonKit an integral part of the everyday lives of individuals. CarbonKit consists of five modules linking personal carbon tracking, fitness and health, social media, and economic incentives (Guzman, Makonin, & Clapp, 2016).

Furthermore, in 2019, a carbon footprint mobile application, Salva is developed to calculate carbon footprint of individuals by using financial transaction data. Salva is a novel

approach carbon calculator mobile application that is available to use in Sweden. It can estimate users' carbon footprint by means of a hybrid approach that relies on financial transaction data from the users' bank paired with environmental extended input output analysis; data from official registers of governmental agencies, and data entered by the users themselves (Andersson, 2020).

**Evaluation method for carbon footprint calculator**

A study has been carried out to investigate the usability of a proposed carbon footprint calculator called Mau Carbon Footprint, and provides recommendations to improve this quality attribute of such tools. For this study the usability study was conducted involving 32 participants who used the tool and were asked to rate it based on the concepts of usability of Nielsen. Five quality attributes of usability were evaluated in this process, which are learnability, efficiency, memorability, errors, and satisfaction, each comprising different measured objects. Learnability and satisfaction were highest ratings among these attributes, while efficiency had the lowest ranking. As a result, an overall mean score of 3.98 for the usability of the proposed calculator was obtained (Bekaroo et al., 2019).