2015

“Tracking the environmental footprint of business activities”

Corina Ionescu
University of Wollongong, ci02@uowmail.edu.au

“Tracking the Environmental Footprint of Business Activities”

Corina Ionescu

This thesis is presented as part of the requirements for the award of the Degree of Master of Philosophy at the University of Wollongong

Sydney Business School

March 2015

THESIS CERTIFICATION

I, Corina Ionescu, declare that this thesis, submitted in fulfilment of the requirements for the award of Master of Philosophy, in the Sydney Business School, Faculty of Business, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

……………………………………………….

Corina Ionescu

Date: …………………………………………

CONTENTS

GLOSSARY

Green House Gases (GHG): The primary greenhouse gases in Earth's atmosphere are water, carbon dioxide, methane, nitrous oxide and ozone.

Small and Medium Enterprises (SMEs): SMEs are based on the number of employees, turnover/ balance sheet total, and ownership. In Australia a small enterprise can have between one and fifty employees and a medium enterprise fewer than 200.

National Greenhouse and Energy Reporting Scheme (NGERS): The scheme was established by the National Greenhouse and Energy Reporting Act in 2007. It is a single national framework for reporting and disseminating company information about the greenhouse gas emissions, energy production, energy consumption and other information specified under NGERS legislation.

Intergovernmental Panel on Climate Change (IPCC): Issues the Assessment Reports that provides a clear and up to date view of the current state of scientific knowledge relevant to climate change

Carbon Footprint: The total set of greenhouse gas emissions caused by individual, event, organisation, product, and expressed as Carbon Dioxide Equivalents (CO2e)

Carbon Calculator: An application to determine a Carbon Footprint where calculations are typically based on annual CO2e emissions from a device in the previous 12 months.

Environmental Footprint: Within the Environmental Footprint are included emissions from all ranges of business activities, primary energy used, management of waste produced by activities, management of water use and land disturbance.

Activity: Is a "dialectic relationship between subject and object"; in other words "who is doing what for what purpose".

Activity Theory: Activity Theory as developed by Vygotsky (1978), Leontiev (1981) and Engetrom (1987). According to this theory, an *activity* is someone or several people (the *subject*) doing something to transform (an *object*) using tools (physical, psychological and cultural) to achieve desired outcomes. These tools can include information systems so that IS researchers find Activity Theory useful.

Carbon Wiki: Would crowd source data on Green House Gas (GHG) or carbon emissions due to business activities anywhere in the world.

Forms: IS artefacts, designed as input Forms to a Wiki based on Templates of activities related to business activities in different industries.

Template: IS artefacts, designed to structure an appropriate Dashboard interface to the Wiki and support the user experience for different industries.

Dashboard: The Dashboard is an interface to an information system in a format that allows end-user managers of Small and Medium Enterprises (SMEs) to determine and track the contributions to the environmental footprint of their various business *activities*.

Scope 1 ,2 ,3: Scope 1 (direct GHG emissions), Scope 2 (non-renewable energy use) and Scope 3 (indirect GHG emissions). Used in NGERS reporting

ABSTRACT

The research reported in this thesis is motivated by concerns that have been raised for more than forty years about the deterioration of the environment associated with human activities, in particular the consequences of Green House Gas (GHG) emissions.

This thesis describes the design of a freely available online information system in a format of an end-user online Dashboard that would enable managers of Small and Medium Enterprises (SMEs) to determine and track the contributions to the environmental footprint of their various business *activities*. While large organisations have the resources to do this, SMEs need an application that is low cost and easy to use. The study aimed to supplement an existing project involving the building of a Carbon Wiki which would crowd source data on Green House Gas (GHG) or carbon emissions due to business activities anywhere in the world.

There are many online Carbon Calculators that can help people estimate the amount of emissions associated with *things* such as vehicles for transport, plant and machinery of all kinds, office equipment and so on. These are either direct emissions (e.g. truck exhausts) or indirect emissions due to equipment which uses electrical energy from non-renewable sources. Businesses can take steps to be more environmentally responsible by reducing their use of *things* that pollute the environment or by choosing equipment that is more environmentally friendly; but this will only get you so far. Further gains need a more holistic approach that looks at different ways of working.

The research described in this thesis takes a Design Science approach to the creation of the Dashboard. Using data in the Wiki, the Dashboard interface would allow SMEs to estimate the GHG emissions of whole *activities* rather than individual *things.* As *activity* is the pivotal design component in the design of the Dashboard the research logically uses ideas from Activity Theory and Design Science Theory. While there is an obvious practical contribution of the research to the development of a Dashboard there is also a theoretical contribution to Design Theory. This comes through the contradictions discovered between the activities of the Wiki and Dashboard designs in respect of the structure of data. The conceptual learning that occurs through contradictions is well understood in Activity Theory and here is applied to expand Design Science.

Key words: Green House Gas (GHG), Small and Medium Enterprises (SMEs), Activity, Carbon Footprint, Activity Theory, Wiki, Carbon, Forms, Dashboard.

INTRODUCTION

"Sustainable Development is meeting the needs of current citizens without compromising the ability of future generations to meet their own needs"

Brundtland 1987

1.1 Research Topic and Motivation

This research looks at the role of Small and Medium Business (SME) in regard to the environmental impact of their businesses. SME owners are often socially responsible by nature, while the size of a small business constrains their ability to take responsible action. (Lepoutre and Heene 2006). SMEs must weigh the cost involved in changing to more environmentally responsible and sustainable ways of operating (Bos-Brouwers, 2010). SMEs need innovative ways to find the resources to assess and track their Environmental Footprint in order to find ways to reduce it. This thesis looks for a solution to this problem.

The research reported in this thesis is motivated by the concerns that have been raised for more than forty years about the deterioration of the environment associated with human activities, in particular the consequence of Green House Gas (GHG) emissions. Building an environmentally responsible eco-civilisation is becoming one of the main elements of the future vision of governments, businesses, non-government organisations (NGOs) and other interested groups. The consumption model that we have witnessed in the last twenty years is slowly destroying the "Earth's life-support systems, ecosystems and environment" (Wang & Zhang 2001). This has manifested itself in the United Nations' (UN) focus on responsible sustainable development. One of the first initiatives in this area was raised in 1972 at a UN Conference on the Human Environment in Stockholm (UNCHE, 2007). Later, in 1980, the world leaders started to become more conscious of problems created by the heavy use of resources through industrialisation. A new international organisation was launched named the World Conservation Strategy (McCormick, 1986) which combined several existing environmental organisations at that time including the International Union for the Conservation of Nature and Natural Resources (IUCN), the UN Environmental Program (UNEP) and World Wildlife Fund (WWF) together with the United Nations Educational, Scientific and Cultural Organization (UNESCO). The World Conservation Strategy is now

present in more than thirty countries which are following the guidelines suggested by this environmental authority.

From its inception the purpose of the World Conservation Strategy was to develop sustainable solutions to global problems of degradation to the environment. Three years later, in 1983, the Secretary of the United Nations and its Assembly decided to ask the Prime Minister of Norway, Gro Harlem Brundtland, to establish a new organisation independent of the UN, known nowadays as the Brundtland Commission, aiming to unite countries with the goal of sharing the environmental problems and solutions in order to develop a sustainable future. The Brundtland Commission's definition of sustainable development is now widely accepted, i.e. "meeting the needs of current citizens without compromising the ability of future generations to meet their own needs". (Brundtland, 1987).

As a consequence many developed countries decided to implement a set of regulations in order to protect and conserve the environment for future generations. Australia is one of these countries and has implemented a reporting system for large corporations based on Scope 1 (direct GHG emissions), Scope 2 (non-renewable energy use) and Scope 3 (indirect GHG emissions). These reports are recorded in the database of the National Government Emissions Reporting Scheme (NGERS). However, under this scheme Small and Medium Enterprises, (SMEs), are not yet required to keep a record of the emissions produced by their activities. Nevertheless, environmental experts and researchers consider one of their social responsibilities is to educate and possibly regulate SMEs to embrace sustainable business practices. These are desirable not only for the benefit of the environment but will also result in cost savings in many cases.

The project reported in this thesis is a response to the need for systems to help inform the sustainability needs of SMEs who are not yet required to report through the NGERS authority. While concerned about their impact on the environment and their reputation as a green business, they do not have the expertise nor can they afford to allocate resources to this. The project reported here is part of the Green Information Systems (Green IS) movement to discover how IS can help in this regard.

1.2 Research Aims and Objectives

At the onset of the project an audit was conducted of the free online Carbon Calculators that SMEs might use to calculate and monitor their Carbon Footprint. This showed that such calculators were all about *thing**s*** (vehicles, heaters, air conditioning systems, IT desktops and

servers etc.). However, feedback from initial discussions with SMEs revealed they were more focused on their business *activities* such as producing goods and services, delivering goods to customers or maintaining a suitable office temperature. They needed to know how to conduct these activities in a more environmentally and cost-effective way.

The aim of the project then became to find a way to produce a free online application whereby SMEs could easily estimate the Environmental Footprints of the *activities* of their business and thus provide guidance on which of these could be realistically reduced. The contribution of IS to the environmental responsibility of SMEs is investigated by identifying those activities that have a substantial Environmental Footprint and by studying ways to evaluate and track the footprint of these activities. The study involved SMEs from different industries in the Illawarra region of NSW Australia.

The objective of the project was to design a computer-based application that would provide information in a targeted and easy-to-use form to support SME decision-making on environmentally responsible ways to conducting their business activities. This will be a significant contribution towards building a Green Information System to help SMEs achieve more environmentally sustainable business practices in different industries across the Illawarra region and beyond. Most of the businesses are small but if they all make some effort a transformation of their business activities from the traditional approach to the green approach will improve the environment of the entire region.

In order to conduct research to identify, understand and develop such an application, a suitable theory was needed to underpin and guide the research. As the focus was on business activities the most obvious choice was the Activity Theory as developed by Vygotsky (1978), Leontiev (1981) and Engetrom (1987) according to (Hasan et al. 1998). According to this theory, an *activity* is someone or several people (the *subject*) doing something to transform (an *object*) using tools (physical, psychological and cultural) to achieve desired outcomes. These tools can include information systems so that IS researchers find Activity Theory useful (Hasan et. al, 1998, 2001; Kuutti & Molin-Juustila, 1998 in Hasan et. al 1998; Chen et al 2013).

This project concerns the requirements, elucidation and design of an online information system that would enable managers of SMEs to determine which of their business activities have substantial Environmental Footprints and track the contributions of these business

activities to their total Environmental Footprint over time. Although SMES are not yet required to report their Scope 1 and 2 GHG emissions annually through the NGERS, as are large Australian organisations, SMEs may be in the future. Many managers and owners of SMEs are concerned about the environment and would like to reduce their footprint if possible. As a consequence they would like to measure this aspect of their business. Most SMEs do not have the knowledge, resources or time to do this. This project is about how a freely available online information system could be designed to allow them to do this.

When the project here began, another research project supported by the University's Social Innovation Network was investigating ways to determine the Environmental Footprint of activities, using IT in the form of a Carbon Wiki. This other project endeavoured to develop the wiki and crowd source content. My project aimed to add to this project the understanding that would lead to the development of a Dashboard interface to allow managers to easily extract and manipulate data in the Wiki relevant to their business. This would be done by determining through a series of interviews with SME managers the profile of a business in each industry sector to identify the typical daily business activities in each industry. Templates would then be designed to structure an appropriate Dashboard interface to the wiki and support the user experience.

This project was originally conceived as being the relatively straightforward design of the Dashboard interface as an add-on to the working Carbon Wiki that would be filled with content and structured in such a way that extraction of data for the Dashboard would be relatively easy. However, it became apparent that the Carbon Wiki was not suitably designed to collect data, and was never populated with data so a secondary aim of the project was to redesign the Forms to collect data for the Wiki in addition to the design of the Dashboard interface for end-users of the content.

1.3 The Research Problem and SME Context

SMEs represent around 90% of the world's enterprises. (Hillary, 2000). Most definitions of SMSs are based on the number of employees, turnover/ balance sheet total, and ownership. ((Hillary, 2000). In Australia a small enterprise can have between one and fifty employees and a medium enterprise fewer than 200. (Hillary, 2000).

Despite making a significant contribution to global economies these enterprises experience many challenges compared with the big corporations. Some of these challenges are possibly limited access to finance, less adaptability to market changes and lack of human resources.

Consequently SMEs face difficulties in managing new pressures such as environmental regulations or concerns of their stakeholders about their environmental impact. (Hillary 2000).

This topic has a huge importance in today’s society. Many businesses realise the impact of their daily activities on the environment and how essential it is to change to more environmentally sustainable business practices. (Watson et al.2010).

In the last several years more and more businesses have started to embrace the concept of Green Business Activities. While there is information on the carbon emissions and energy consumption of things (cars, computers, equipment etc), there is little information regarding the emission of CO_2 released into the environment or the energy consumption per business activity.

There are growing imperatives for each business to investigate how to determine its total Environmental Footprint and to find ways to reduce it. Large firms in Australia devote considerable resources doing this because of government reporting requirements, but small businesses are unlikely to have the required incentives, time, expertise or budget. (Hillary, 2000).

There are some freely available online resources that could be used. However, most relevant online applications focus on the calculation of Carbon Footprint emitted by things such as cars, computers, printers, heaters, or air conditioners.

In 2012, when this research began, a Google search of the Internet revealed that available web-based calculations of Carbon Footprints were about things such as: cars, air conditioners, heaters, etc. Figure 1.1 illustrates a Carbon Footprint calculator for a vehicle based on mileage, type of car, year of production and efficiency.

In recent years, web-based Carbon Footprint calculations have improved considerably, becoming more complex, taking into consideration more variables, however they are still based on “things” such as equipment.

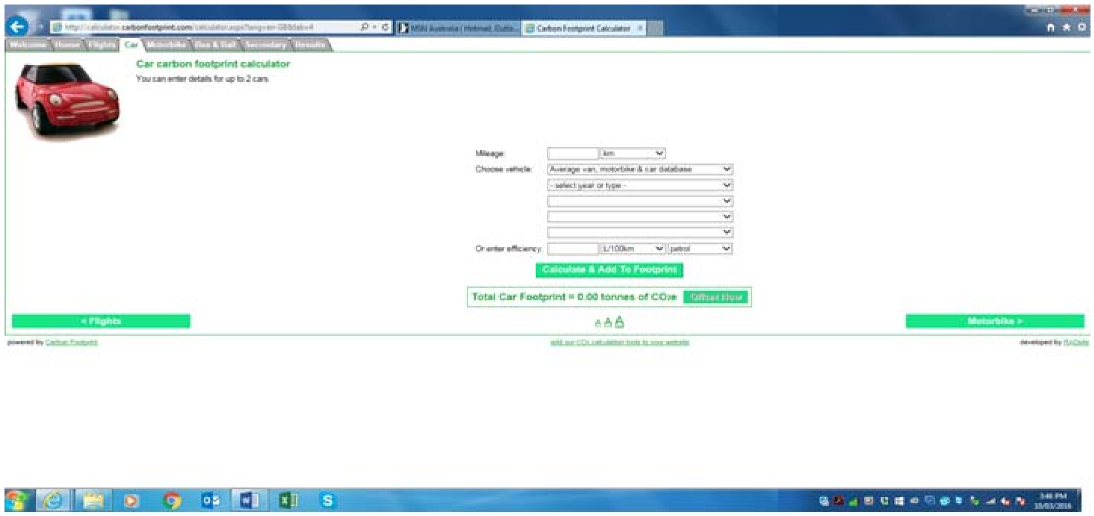


Figure 1.1. A typical Carbon Footprint Calculator [1]

My initial investigation found that managers are more interested in the activities of their businesses not the things and machines they use that can often change. Hence, the measurement of total Environmental Footprints of activities is more complex and requires a more holistic approach, where the decision makers view their businesses as a set of activities and not a sum of equipment and tools.

Many SMSs want to take action based on either a desire to reduce emissions or alternatively on the anticipated need to do so for business costs or regulatory reasons. A simple-to-use, online system through which they could identify and track the environmental footprint of their business would overcome the problems of lack of knowledge, resources and time. Despite the prevalence of various Carbon Calculators for devices, there is not yet any real online IT support for sets of business activities. This research will address this deficit.

1.4 Research Aim

The aim of the project was to investigate the design of an online information system that would consist of a Dashboard interface fed by data collected in the Carbon Wiki concurrently being developed by other colleagues. The Dashboard interface would be made freely available online and would enable an SME business manager to estimate the environmental

[1] http://calculator.carbonfootprint.com/calculator.aspx?lang=en-GB&tab=4

footprint of their business, guided by a template of typical activities in their industry. The end-user would start by selecting their industry and then select those activities offered by the Dashboard for that industry. Relevant estimates of the Environmental Footprint for those activities would then be listed from entries in the wiki and the user would select one to calculate their footprint. The Dashboard would allow the user to enter parameters for this calculation, e.g. the size of a room to heat and the average temperature rise required.

The project would involve: (1) an investigation into the typical activities of businesses in common industries, (2) the creation of Templates of the activities for each industry and (3) the design of the Dashboard using these Templates. Where possible the Environmental Footprint is estimated in CO_2 equivalents.

As previously mentioned it was initially assumed that the Carbon Wiki would be fully developed and populated in a separate project. However as this did not eventuate my project also involved the design of Forms for input into the Carbon Wiki that would collect data in a form that would support the extraction of data to be used by the Dashboard. This need to re-design another part of the information systems from end-user requirements discovered late in the project was interesting from a design science perspective and was subsequently analysed as such.

1.5 Research Methodology and intended Outputs

As indicated above, the nature of the research problem indicated that Activity Theory would be used to guide the research and its interpretation. As the aim was to design an artefact called Dashboard, a constructivist paradigm was adopted. Because of the unexpected need to design an earlier part of the project being undertaken by others, a design science component was added to the research design.

1.6 Contributions of the Research

In the last decade more researchers and practitioners realised the importance of alignment between the technology of IT, information systems and business practices. Mostly, the interest arose with the increasing recognition in the Resource-Based View (RBV) of the firm and the imbalance between the availability of limited natural resources and their increasing consumption. The global ecosystem’s equilibrium started to degrade as a consequence. Moreover in times of economic constraints, cost reductions through use of less energy is a sensible and common strategy shared by all businesses. Consequently, considering the above

aspects together with the advent of the field of Corporate Responsibility (CR), businesses are now beginning to take seriously aspects of Green IT and IS within their practices in order to reduce costs and plan sustainable business activities for the future generations.

The Green IS academic literature reflects the need for both IT and IS to have a green approach that will inform the greening of an organisation's activities. This research will contribute to this literature by demonstrating the advantage of focusing on whole business activities, not just on the individual things used by the business. This is particularly relevant in making it easier for the managers of SMEs to estimate and track their Environmental Footprints.

The research also added to the literature in the area of design science because of the unexpected complication of the project where, during the design of the end-user Dashboard interface, the need to resign an earlier phase of the project became necessary.

The output of the investigation will produce industry-specific design Templates of activities that can assist in the creation of online whole-of-business Environmental Footprint Calculators. Thus this research has a contribution to practice.

Nevertheless, along the duration of the research several obstacles were present and amended in order to complete the final outcome. The first encounter was the additional search of business activities, because the Crowd Source Carbon Wiki repository did not provide enough necessary data for designing an effective online Environmental Footprint Calculator. The following encounters followed as a result of restructured of data. The creation of Templates and the redesign of Forms consisted of the main changes as a result of the appeared complications. Another important change in/of the research flow is the application of Activity Theory to Design Science as a consequence of the contradictions between the two theories.

1.7 Outline of the Thesis

Chapter 2 presents/contains the *Literature Review* of the thesis. In the literature review the following topics are covered: climate change agreements, regulations and changes, specific business activities of SMEs, challenges of SMEs, sustainability in business environment, calculators of things, Dashboard design issues.

Chapter 3 presents the *Methodology* with the research questions, the two research theories are described, the research paradigm and the research plan are also presented.

Chapter 4 presents the *Result and Findings* content, describing the four phases and scenarios of the navigation of the Dashboard.

Chapter 5 presents the *Discussion and Theory Building* of the thesis.

Chapter 6 presents the *Conclusion* of the thesis where research questions are answered, the two contributions - to practice and theory - are described, limitations are presented and future work underlined.

2 LITERATURE REVIEW

2.1 Introduction to the Literature Review

This research is motivated by concern for the environment and the responsibility of the discipline of Information Systems to assist with efforts of sustainable development. These efforts are driven by public debate on climate change and the responsibility of governments, business and community to mitigate the harmful effects of Green House Gases (GHG) emissions from human activities. However, the problem is a complex one and it is difficult to know what would be the best decision to take in any particular circumstance.

The Australian government has introduced the National Government Emissions Reporting Scheme (NGERS) that requires large companies to report on their Scope 1 (direct) and Scope 2 (indirect) GHG emissions. However this does not cover the whole spectrum of a business's Environmental Footprint. It does not require any reporting on the direct or indirect emissions from SMEs. Also, harm to the environment comes not only from primary or secondary GHG emissions but also from waste and other indirect sources.

Lepoutre and Heene (2006), consider that there are two points of view regarding small businesses and their social responsibility. Some argue that small businesses are socially responsible by nature, while others argue that the size of a small business implies barriers, and therefore they are constrained to take responsible action.

It is clear that businesses cannot stop operating just because they have an environmental footprint. Changing entrenched environmentally damaging ways of working can be difficult and expensive. SMEs in particular cannot afford extra cost involved in changing to more environmentally sustainable ways of operating even if they knew how best to do this (Bos-Brouwers, 2010).

SMEs often do not have the resources to investigate ways to assess and track their Environmental Footprint in order to find ways to reduce it. Yet, they often want to undertake this task for several reasons including the prospect of changes in legislation that could require this, well-known benefits to the image of the business of having a 'green' image, and the personal desires of managers to do the right things with respect to the environment. (Quinn, 1997; Hitchens et.al., 2005; Petts et.al., 1999)

It is known that most of the innovative ideas and corporate sustainability applications are for large enterprises therefore, SMEs find it difficult to adapt them to their environment. In Table 1, Bos-Brouwers (2010) summarises many of the characteristics of SMEs.

Table1. Characteristics of SMEs against those of Large Companies (Bos-Brouwers 2010)

SME	Large Company
Dominant role of the entrepreneur/owner	Delegated management control between board of directors and shareholders
Resource poverty (capital, time, knowledge and skilled personnel)	Economy at scale, resource abundance
Flexible organisation capacities	Bureaucratic rigidity
Focus on short term	Focus on mid-to-long term
Strong local/regional focus and customer needs orientation	Strong (inter)national focus and looser ties with customers
Low degree of formalisation	High degree of formalisation

More details on SMEs characteristics and environmental issues are discussed in Chapter 4, Section 4.1, and in Tables 4.3 and 4.4.

This research is aligned with the current message of Green IS that information systems can be a powerful tool in supporting businesses to improve their Environmental Footprint (Watson et al, 2012). One of the ways to do this is by providing information and the tools to manipulate information to monitor and predict. (Watson et al. 2012; Melville, 2010; Elliot, 2011). Many of these types of tools are now freely available on the Internet, predominantly in the form of Carbon Calculators that enable the user to determine the Carbon Footprint of ‘things’.

In this project it is proposed that managers of SMEs would benefit from tools that enabled them to determine the contributions to their Environmental Footprint of their business ‘activities’.

In this Chapter the background literature to this project is presented. It begins with literature on environmental sustainability to support the basic motivation for the project. It then presents Green IS literature to support the proposition that information systems have a role to play to support environmentally sustainable initiatives. Thirdly, literature on Activity Theory and Design Science is presented to support the research approach adopted in the research. Finally, a summary is presented of existing Internet-based information systems tools that are used to develop usable Dashboards to allow SMEs to easily access information about environmental footprints and apply it to the activities of their business.

2.2 Climate Change and Environmental Responsibility

Building a sustainable, environmentally-responsible civilisation should be one of the main elements of the future vision of governments, businesses, NGOs and other interested groups. In the last twenty years we have witnessed a consumption model that is slowly destroying the environment, ecosystems and the earth’s life-support systems (Wang & Zhang 2001)

The concerns that human activities are deteriorating the environment have been raised for more than thirty years. The slogan for environmental action is to “think global and act local” and so I begin with the global context of this challenge.

As mentioned in Chapter One, the World Conservation Strategy was created in 1980 and combined the International Union for the Conservation of Nature and Natural Resources (IUCN), the UN Environmental Program (UNEP), the World Wildlife Fund (WWF) and UNESCO. Three years later, in 1983, a new organisation independent of the UN was formed, informally known as the Brundtland Commission or, more formally, the World Commission on Environment and Development (WCED). The mission of the WCED was to unite countries with the aim of sharing environmental problems and solutions in order to develop a sustainable future. In 1988 the United Nations Environmental Programme (UNEP) and World Meteorological Organisation (WMO) decided to establish a leading inter-governmental body for assessing the research on climate change called the Intergovernmental Panel on Climate

Change (IPCC). [2]From that point there was unprecedented global attention on the consequences of human activities on the environment.

The initial definition of sustainability as defined by the Brundtland Commission (1987) stated that resources should aim to meet current human needs, while conserving the environment in order to meet these needs not just in the present but also for future generations, thus creating sustainable development as a pattern of economic growth.

A few years later in 1987, the Brundtland Commission made another very important contribution to the environmental field through the report “Our Common Future”. The Brundtland Commission emphasised two inseparable entities: “environment” and “development” and their vital relationship. The environment cannot be looked at as a “sphere” that exists separate from “human emotions and action” while development cannot be strictly seen as a “term habitually used to describe political goals or economic progress” (Brundtland, 1987). Rather, the two should be understood as having an ecological interconnection, and that there is a significant relationship between sustainable development and climate change and this has been the focus of many initiatives of the UN. The less sustainable human activities practised in the 20^{th} century is reflected in the severity of the many natural disasters that have since occurred around the world. Most of the natural disasters are believed to be due to changes to the global climate.

The Brundtland report made a significant contribution towards an event that occurred later in Rio de Janeiro in 1992, known as Earth Summit, when Agenda 21 was adopted. This led to one of the most important actions of the United Nations Framework Convention on Climate Change (UNFCCC), the Conference of the Parties (COP), held annually since 1995. At the first COP 37 industrial developed countries were committed to reducing the GHG emissions by five per cent comparing with the 1990 level. This was, for the first time, after 150 years of industry activities that the developed nations finalised an official intergovernmental agreement on reduction of emissions.

A significant breakthrough came at the COP in Japan in 1997 when the Kyoto Protocol was begun with 192 parties involved[3]. The Kyoto Protocol was the initiator of a major document that would require the developed nations to stabilise their GHG and CO2 emissions that are contaminating the atmosphere and increase awareness that “the climate system is a shared

[2] http://ipcc.ch/organization/organization.shtml
[3] http://www.un.org/climatechange/towards-a-climate-agreement/

resource”[4] which, unbalanced, could led to dramatic changes of the ecosystems. While many countries signed up to the Kyoto Protocol some did not, particularly the USA. While the Australian government stated continually that they would meet their targets, they did not actually sign the Kyoto Protocol until a change of government in 2007.

Australia then placed great hope for the COP 15 in Copenhagen. As there was a need to create a new accord when the Kyoto Protocol which was due to expire in 2012. An accord was established by COP 15 in Copenhagen, Denmark in December 2009, regarding reduction of CO2, limiting the increase of temperature to below 2 degrees Celsius by 2020 on current levels. However, it was the Durban COP Conference 17 in 2011 when the parties achieved a significant outcome “to adopt a universal legal agreement on climate change as soon as possible and no later than 2015”.[5]

The Paris conference in 2015 will thus be an important one to keep the momentum going. The leading international environmental scientific body the IPPC has its headquarters placed in Geneva, Switzerland, where decisions, documents and reports are elaborated and made public in order to inform the public at large about different issues related to climate change[6]. The IPCC invites thousands of volunteering scientists from all over the world to take on the role of authors, contributors and reviewers, together with their technical support. This large knowledgeable group meets to agree on a number of important decisions to be made and reports and documents to be published. This panel organised the most recent 48th session of IPCC on 27 January 2015.[7] Despite the criticisms of some so-called climate sceptics, the IPCC reports are generally accepted as authoritative information on the causes, current state and future projections of climate change.

In June 2012, the 20-year anniversary of the first Earth Summit in Rio de Janeiro, Brazil was marked by a crucial event that was organised by the UN on sustainable development. The event, one of the largest international gatherings, was called Rio +20 The United Nations Conference on Sustainable Development. The Australian Government, who made a significant contribution towards the preparation of the event, was one of the many participant

4 http://unfccc.int/key_documents/the_convention/items/2853.php

5 http://unfccc.int/meetings/durban_nov_2011/meeting/6245/php/view/decisions.ph

6 http://www.ipcc.ch/index.htm.
7 http://ipcc.ch/scripts/_session_template.php?page=_35ipcc.htm

countries and its representatives comprised one of the thousands of government members, private sector, NGOs and other groups.

The Rio +20 meeting had on its agenda a few items of crucial importance to be addressed and to be embraced as future goals by the audience. The seven items presented as major priorities for Australia were: water, food security and sustainable agriculture, oceans, energy, decent jobs and disaster readiness. [8]

In order to have a common ground in implementing the main three dimensions: green economy, sustainable development and eradication of poverty, the Rio +20 Conference issued an important document entitled "The Future We Want".[9] The outcome document is organised in six sections that make two hundred and eighty three points agreed by the leaders of all participant countries. All points are of equal and significant importance, however most relevant to the research in this thesis are only three points that even make mention of the information and communication technology (ICT) as listed below. This shows how neglected ICT is among environmental initiatives. There are three main points mentioned within the "The Future We Want" document, as follows:

The first point can be found in the second section of the document titled, "Engaging major groups and other stakeholders", point 44 mentions the role of ICT in the connections between the government and public, in order to facilitate the flow of information between these two stakeholders.

The second point is found under the section titled, "The "Green economy in the context of sustainable development and poverty eradication" which is the third section of the document. This point recognises the powerful role for communication technologies, connection technologies and the vast range of their innovative applications.

The last but not the least point is found in the sixth section of the document with the title "Means of Implementation" under "Technology" where point 274 focuses on the importance of information technology, this time considering one of its applications "space-technology-space data", that monitor the collection of geospatial information, records of crucial significance for "sustainable development policymakers, programming and project

[8] http://www.environment.gov.au/rio/

operations". This point underlines the usefulness of facilitating access to these applications by the developing countries.

Pachauri et al (2014), noted in the IPCC AR5 Synthesis Report that different effective adaptation and mitigation responses will be encounter depending on policies and measures across multiple levels, namely: international, national, regional and sub-national,

Next year in December the UN will organise the COP 21 in Paris, when feather agreements and negations will proceed.[10] It would seem appropriate if research on Green IS could be considered by participants.

2.3 Green Information Systems (IS)

In the last half century, Information Systems (IS) have been one of the greatest forces in improving productivity through the application of information technology (IT). (Avital et. al, 2007). According to Elliot (2011) Information systems (IS) are considered a key element in enabling the organisations and society at large to transform towards more environmental sustainable entities. However, findings show that globally 2% of the GHG emissions come from ICT and will increase to 3% by 2020. Even more significantly this industry is responsible for consumption of more than 7% of all electricity generated in Australia. (Philipson, 2010). The results of poor environmental practices are reflected in waste, unused resources, energy inefficiency, noise, friction and, not least, emissions; while in general past business practices have totally neglected the environment, many organisations currently realise its importance and have initiated Green IS practices. (Watson et al.2010). Melville (2010, pp.1) stated in that "to galvanize IS research on environmental sustainability" can innovatively enhance both the field of IS and the sustainable business practice. It is very important that development meets the needs of the current generation but not compromise the needs of future generation, as this is the core of any definition of sustainability.

The research presented in this thesis contributes to the literature on Green Information Systems (Green IS) and their contribution to sustainable business practices. Despite the acceptance of the importance of Green IS to sustainable business practices, the correlation between IS knowledge and sustainable transformation is "largely absent" from literature (Elliot 2011; Melville 2010; Watson et al. 2010, Seidel et al. 2013).

Loeser (2013) confirms that there are these two research streams that information systems researchers are undertaking in order to contribute to environmental sustainability. In the last decade these two streams, Green IT and Green IS, have sometimes been used interchangeably in the literature. However, more recently with the advent of the realisation of what IT can do to help mitigate climate change the two terms have started to differentiate each other. Green IT focuses on the greening of IT hardware manufacture and uses such as green data centres, green supply chain, use of cloud computing, etc., In contrast, green IS refers to the greening by IT characterised by its holistic approach due to integration of people and procedures to help others reduce their environmental impact.

The climate change challenge is addressed in the both streams (Malhotra et.al, 2013). According to Watson et. al (2010). Green IS represents the larger of the two streams and its focus is on study of design, implementation and impact of information system, within the business processes in support of all environmental initiatives. Green IT has as a narrower focus on the study of technology from IT energy efficiency and IT equipment utilisation (Watson at. al. 2010). Most of the Green IT literature belongs to practitioner reports with some academic articles (CFO, 2009; Gartner 2008; Chen et al. 2008; Elliot 2011; Elliot and Binney 2008).

My research has as its outcome, the design of a Dashboard with the Carbon Wiki as a starting point. The Carbon Wiki was based on BPM (Business Process Models), however these models offer a very detailed view of business activity. In comparison, my research uses Activity Theory to approach business activity in a more holistic way compared with the BPM approach. (Ghose et al., 2010).

Figure 2.1 is presented in an introduction to a special issue on Green IS in MIS Quarterly (Malhotra et. Al', 2013). Figure 2.1 is the most complete overview at this point in the literature review of Green IS and Green IT and locates my area of research in the design position within the whole Green IS research Value Space. Figure 2.1 shows that most of the Green IS literature is mainly located in Conceptualise and Analyse Value Spaces. My research is significant in being among a few studies in the area of Design Research Value Space, where not many contributions have yet been made.

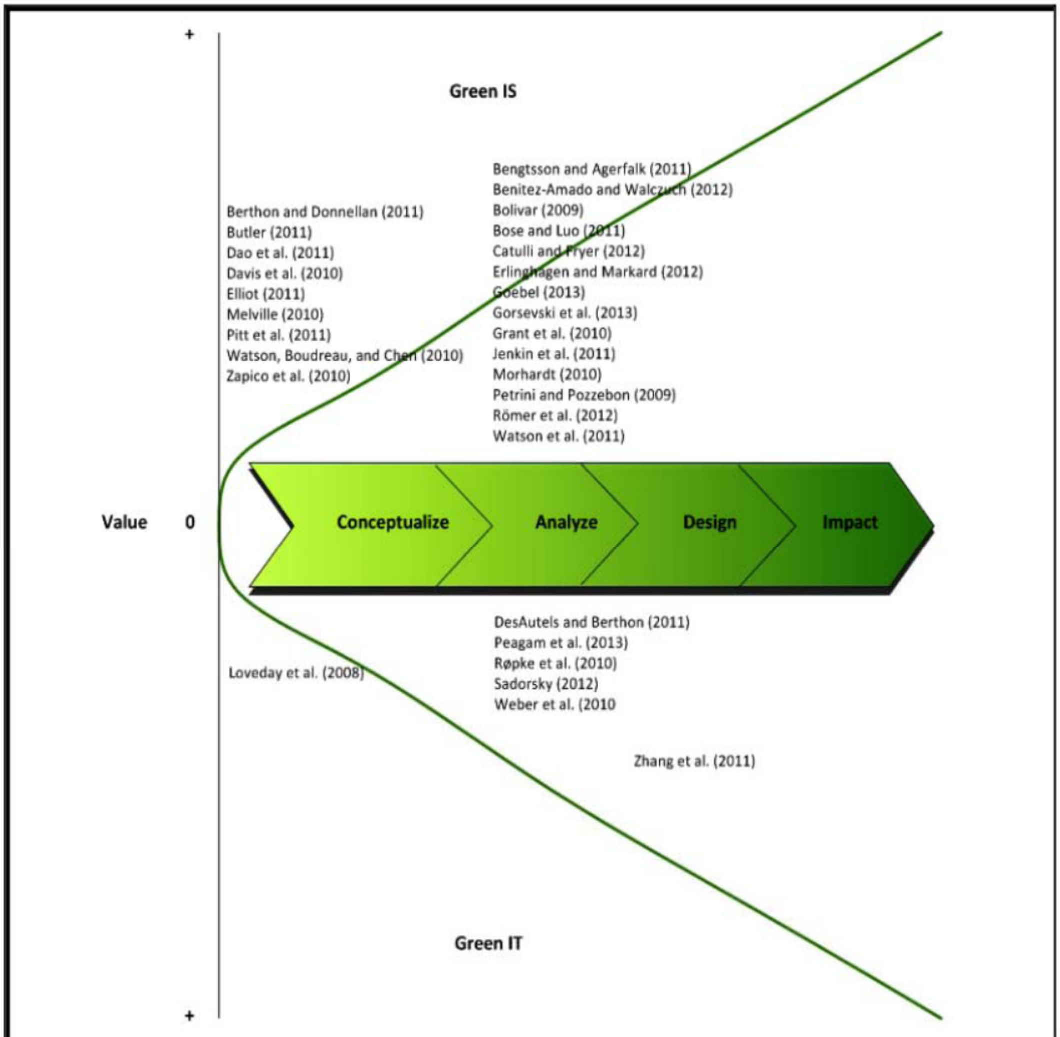


Figure 1. Green IS and Green IT Research Value Space

Figure 2.1. Green IS and Green IT Research Value Space (Malhotra et. al, 2013**)**

Green IS represents an area of intense interest for the field of IS following the pivotal articles by Watson et al (2010) and Melville (2010) in the top journal MIS Quarterly. These articles underline the importance of environmental sustainability to the work of the Information Systems (IS) community through the development of more environmentally responsible practices.

According to Watson et al. (2010), much of the practitioner literature is currently devoted to Green IT. The focus on Green IT is too narrow for the IS community and he states that the IS literature should extend itself to view of information systems, which is an integrated and inclusive of people, processes, software, and information technologies to support individual, organizational, or societal goals. The use of the term Green IT should be replaced with an

encompassing Green IS one, as it incorporates a greater variety of possible initiatives to support sustainable business processes. It is obvious that, Green IS includes Green IT.

Currently, one of the driving elements of the IS research and business practices is **energy** and how IS can contribute to reducing energy consumption and GHG emissions. Watson et al. (2010) propose the development of an Energy Informatics Framework and a new subfield called Energy Informatics. The aim of the Energy Informatics is to analyse, design and implement systems that will increase the efficiency of energy demand and supply (Watson et al.2010). These authors emphasise the importance of Green IS in the following areas: teaching, leadership, research, and writing and IS associations.

Melville (2010) promotes the importance of environmental management systems (EMS), which are programs that require information systems to evaluate, monitor, improve and communicate environmental performance. These have two components, namely: inputs (energy, water, materials, etc.) and outputs (waste, emissions, etc.).

There are several examples of companies which effectively embraced the concept of sustainability and its applicability using IS. Two global enterprises are used as examples of organisations that adopted environmental management strategies (Melville,2010). According to Rose (2008) *Marks and Spencer* is "committed to a five-year plan to reduce its greenhouse gas (GHG) emissions" while Google, according to (Melville, 2010), is an organisation that promotes information generated by a device called Power Meter through the collection of data from smart meters and energy management systems.

The examples could continue with a technology company creating software that stimulates "a smart city online" in order to demonstrate and motivate citizens on the importance of climate and energy issues. Also, a very efficient example of Green IS has been demonstrated by a logistic company that uses "package-flow" software", which changes the route of delivery trucks in a technological manner that will facilitate the following outcomes for the organisation as such: "improved safety, lowered emissions, and cut maintenance expenses" (Malhotra et. al, 2013).

According to Kleindorfer et al. (2005) and Porter and Kramer (2011), sustainability is related to the triple bottom line, which can be understood as a broad conceptualization of organizational performance comprising economic, environmental, and social dimensions.

Related to the triple bottom line in Green IS, the economic and environmental dimensions together with the ability of organisational practices of IS to improve these performance areas, are emphasised in Melville (2010). This author contributed a framework of micro processes to demonstrate (1) how employees learn about sustainability issues, (2) how managers develop and implement effective action plans involving information and IS, (3) what types of new information are required, (4) how such information is used, and (5) how new information systems are designed.

This framework is used to develop a research agenda on IS for environmental sustainability and the agenda focuses on informing beliefs, enabling actions, and transforming outcomes. (Melville, 2010).

Many practitioners have designed green information systems for calculating emissions from using “things” but not from business activities. This suggests that to measure emissions as a result of business processes and activities is difficult. For example in order to conduct sustainable business activities in a logistics company improved safety, lowered emissions, and reduced maintenance expenses it would be necessary to gather route data every day for every truck and analysing these data streams” (Watson et.al, 2010). Many large corporations are designing applications that will enhance their value chain activities, therefore adding economical and environmental value to the organisation. (Malhotra et al, 2013).

One recent academic study by Seidel et al (2013), emphasises that IS not just enables organisations to reduce carbon emissions but also, using business intelligent systems, the organisations can support more sustainable sense-making or decision-making processes having access to environmental data. This work is one of the only examples of Green IS in the Design Value Space (Malhotra et. al, 2013) shown in Figure 2.1

Based on this literature review on Green IS and the recent overview by Malhotra et. al. (2013) referring back to Figure 2.1 I conclude that most of the studies are in the Conceptualize and Analyse Value Space and partly in Design Value Space. My thesis addresses that part of the Design Value Space, thus filling a void in the literature.

2.4 Determining and tracking an Environmental Footprint

The conduct of business activities invariably consumes a range of different resources many of which are non-renewable. Their energy use results in many different emissions that go into

in the environment. As a consequence negative changes have occurred over time around the globe deteriorating the quality of the ecosystems. More and more scientists, academics and leaders consider that rules and regulations should be implemented to reduce GHG emission. Many people use the popular term Carbon Footprint to signify this.

One part of the solution is the measurement of the Carbon Footprint as applied to businesses. To do this it will be necessary to measure the emission coming directly from their activities and from the purchase of energy (Matthews et. al, 2008, pp.5840). However, the Environmental Footprint solution is not a holistic measurement considering that it doesn't take into consideration other impacts of business activities on the environment such as e-waste. In this research the term Environmental Footprint is used as a more holistic measurement. Within the Environmental Footprint are included emissions from all ranges of business activities, primary energy used, management of waste produced by activities, management of water use and land disturbance. (Foran et al, 2005).

The contributions to the Environmental Footprints of large business are commonly studied in the literature and are the current focus of government regulation.

The Australian government introduced a National Greenhouse and Energy Reporting Act (NGER) in 2007. According to this Act every Corporation which meets the threshold must report its greenhouse emissions, energy use and energy production.

There are 7 steps that the corporation should undertake under the NGER Framework:

Step 1: The step implies to determine if the company needs the reporting threshold

Step 2: Determine the controlling corporation

Step 3; Define the controlling corporation's group

Step 4: Identify your group's facilities and who has operational control

Step 5: Apply the threshold to your group and facilities

Step 6: Apply for registration

Step 7: Prepare and submit your report

The Government website provides threshold estimators for corporations that can be used to calculate an approximation of the greenhouse emissions in tonnes carbon dioxide equivalents CO2e, energy consumption and production. There are calculators for solid waste and

wastewater included under the estimator section of the website. As a result an assessment will be issued.

The threshold requirement excludes SMEs from the process at this point in time, although they may be requested to report in the future.

Another Act issued by the Government is a second single document called the Clean Energy Act 2011. The Act is a result of the negotiations and commitments made under the Convention on Climate Change and Kyoto Protocol of reducing emissions, and therefore the Act encourages the use of clean alternative sources of energy.[11]

2.5 Activity Theory and IS

As activities are the object of focus in this study, Activity Theory is an appropriate theory to be used as the framework for this study. Activity Theory is also known as the Cultural-historical Activity Theory (CHAT). The theory was first developed by the Russian psychologist Vygotsky (1978) and Leontiev (1981). More recently, Engestrom (1987) introduced the concept of "collective activity system" that extended, the Activity Theory.

The main advantage that Activity Theory offers is in an understanding of how people subjectively interpret what they are doing and how tools such as IS mediate what they are doing. (Hasan, 1998).

The theory underlines three main characteristics of activities. The first characteristic of the activities is the hierarchical nature whereby an activity is a high-level construct that is composed of a set of actions and operations (Leontiev, 1981). The second characteristic is that the activities are mediated by tools which can be physical or psychological. The last attribute consists in considering the activity not as a separate entity but interrelated with the cultural and historical environment in which they occur (Kaptelinin 1996).

[11](http://www.cleanenergyregulator.gov.au/National-Greenhouse-and-Energy-Reporting/Pages/default.aspx

Using an Activity Theory framework for IS research takes activity as the unit of analysis where activity was defined by Vygotsky (1978) as a “dialectic relationship between subject and object”; in other words “who is doing what for what purpose”. The relationship is dialectic in the sense that while the “doing” is done with a material or psychological objective purpose it is also subjectively interpreted by the doer (Hasan & Banna, 2010). Engestrom (1987) adds to the two dimensional structure of Vygotsky the social infrastructure of activity as depicted in Figure 2.2. Table 2.1 explains how this is used as a research framework which is encompassing the following elements: subject, object, tools, rules, division of labour and community. (Engestrom. 1987).

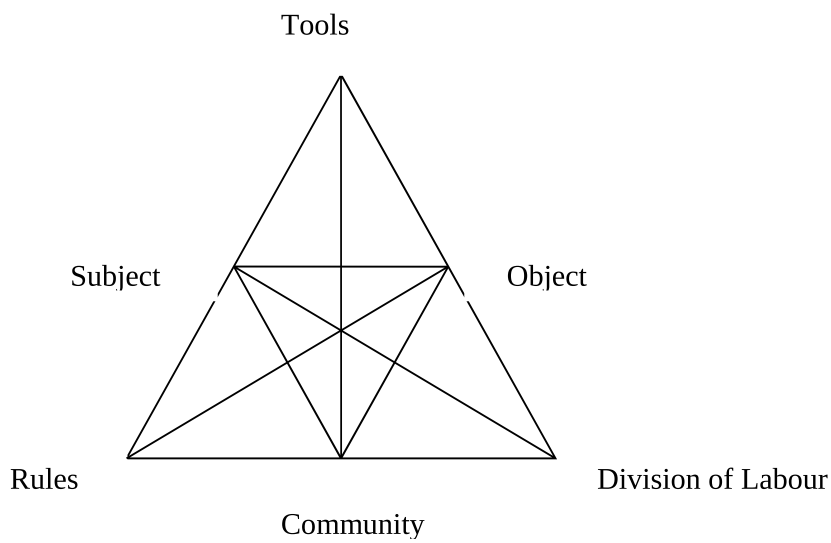


Figure 2.2. The socially distributed Activity System (Engestrom 1987)

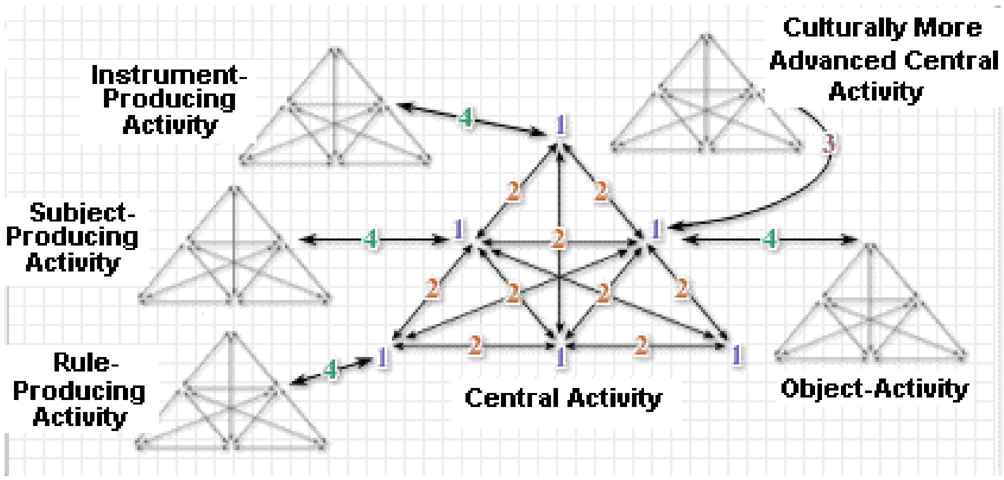
Table 2.1: The Main Elements of Activity Theory (Engestrom 1987)

Activity	What sort of activity am I interested in?
Objective	Why is the activity taking place?
Subjects	Who is involved in carrying out the activity?
Tools	By what Means are the subjects performing activity?
Rules and Regulations	Are there any cultural norms, rules, or regulations governing the performance of the activity?
Division of Labour	Who are responsible for what, when carrying out activity and how are those roles organised?
Community	What is the environment in which this activity is being carried out?
Outcomes	What is the desired outcome from carrying out this activity?

Most researchers who embraced CHAT agreed with the idea that the subject can be an individual of a collective, such as a work group. Engestrom (2000) added a new dimension to the theory regarding the tensions and contradictions within and between systems of activities.

The contradictions that are encountered during activity can provide opportunities for change, learning and the creation of a new socio, technical, economical and environmental systems.

The four different types of contradiction classified by Engestrom (2000) are shown in Figure 2.3



1 are primary contradictions within each constituent component of an activity, often between the exchange value and the use value within each.
2 are secondary contradictions between the constituents of an activity.
3 are tertiary contradictions between the object/motive of the dominant form of the activity and the object/motive of a culturally more advanced form of the activity.
4 are quaternary contradictions between an activity of interest and its neighbor activities.

Figure 2.3 The four types of contractions within and between activities

According to Engestrom (2000) on different contradictions the following issues are encountered in this study:

One issue that can arise in the use/purpose of Forms/Dashboard by the businesses is not fully understood the regulations or the data quality stored in the wiki doesn't meet the business needs. The introduction of the Dashboard can be assimilated with a "culturally advanced object" (Engestrom, 2000) which can cause contradictions as well as acceptance and improvement while the businesses become more aware of advantages/opportunities in embracing the green practices. The third important aspect that can turn into a tension within the business activities is the costs involved in green practices and between the business and their customers who can be influenced to prefer the purchase the environmental friendly products or use of the more environmental/ecological oriented services.

The concept of contradictions between activities plays an important role in the analysis of this project as described in Chapter 5.

2.6 Design Science

Design science as an IS research paradigm where an important dichotomy must be faced. Design is both a process (a set of activities, a verb) and a product (an artefact, a noun) (Walls et al. 1992). It describes the world as acted upon (processes) and the world as sensed (artefacts). This view of design supports a problem-solving paradigm that continuously shifts perspective between design processes and designed artefacts for the same complex problem. The design process is a sequence of expert activities that produces an innovative product (i.e. the design artefact). The evaluation of the artefact then provides feedback information and a better understanding of the problem in order to improve both the quality of the product and the research findings (Walls, et.al, 1992).

According to Hevner (2004), IT artefacts are dependent on people as well as the organizational and social contexts in which they are used in meeting business needs. They cannot be understood independent of this context. Hence, it should be an acknowledgment that perceptions and fit with an organization are crucial to the successful development and implementation of an information system.

In Design Science the following fundamental principal is core; that knowledge and understanding of a design problem and its solution are acquired in the building and application of an artefact.

There are several definitions of Design Science of which the following two definitions are the most significant relevant to the current research:

According to (Walls et al., 1992), Design Science is a research paradigm in which a designer answers questions relevant to humans via the creation of innovation artefacts, therefore new knowledge is created and added to the body of knowledge in Information Systems. Peffers et. al. (2007), considerate that both natural sciences and social sciences try to understand reality, while Design Science attempts to create things that serve human purposes.

The steps followed in designing the Dashboard and redesign of Wiki for crowd sourcing are very similar to the steps presented by Peffers, et.al (2008, pp.52-57), and consist of the following:

1. Identify the problem
2. Define the obstacles in reaching a solution
3. Design and Development

4. Demonstration of the solution
5. Evolution of theory and reflection
6. Communication – the findings

Design science introduces the element of potentiality considering that a new idea or artefact can become an opportunity that improves practice until the practitioners may recognise any problems. Examples include relational data models and the first ideas of object-orientation.

March and Smith (1995) stated that the design science in IS concerns artefacts that are designed and built by man to accomplish the purposes of man. Orlikowski and Iacono (2001) introduced the phrase 'IT artefact' within the IS research community. IT artefacts are defined as a packaged of material and cultural properties in a socially recognizable form such as hardware and/or software (Orlikowski and Iacono, 2001).

At the same time with the introduction of IT artefact concept, new theories started to develop theories that before did not use the computers as a predominant of unique medium. According to Niiniluoto (1999) the artefacts without the existence of theories, "do not have any truth value, and theories that describe and explain reality outside our mind have truth as correspondence". On the other hand the theories can prove that they are legitimate "if practical action informed by a theory consistently proves to be successful" (Bunge, 1967).

Bunge (1967) stated that "in the design science research context the conventional criterion is a significant goal in the sense that the artefact (e.g. a new systems development method OO+++) will be accepted as a valid instance of some class concept (e.g. object-oriented methods) by a relevant community (e.g. by practitioners). Despite this, I do not think that it is an inherent aspect of the artefact, since the artefact may achieve general community acceptance years after its invention and construction".

Considering the different nature of research - basic research and applied research - the old dichotomy between the two can be replaced by descriptive research and design research based on different knowledge claims, Niiniluoto (1993).

This lead to the existence of products knowledge as a "separate category in design science".

According to Nunamaker et. al, (1990-1991; March and Smith (1995); Hevner et al. (2004) building artefacts in design science is a creative process. This imaginative process is possible considering that the artefacts should not "describe or explain any existing reality". Examples are the IT artefacts such as computer games, computer art and computer pets; these do not

require laws of nature in their construction. The imaginative element of artefacts construction makes it difficult to find an appropriate definition of a method used in design science activity of artefacts building.

Based on the common goal of changing the world, design science can be also assimilated with action research (Burstein and Gregor 1999; Järvinen 2007). However, the two categories of research should be separate conceptual entities considering several points are different. These include: history, practicality, ontology, epistemology and methodology. Moreover, action research “has its roots in Kurt Lewin and the socio-technical design movement” according to Baskerville and Myers (2004), comparing with design science research with roots in engineering. Another important point of view according to van Aken (2004) regarding the two is way of approaching the design of different artefacts: action research focuses on improvements problems rather than construction problems.

According to March and Smith(1995) design science “consists of two basic activities, build and evaluate”, one of them “build” is used in the construction process of the Dashboard as a main activity used to create an artefact which performs in accordance with its environment (March & Smith,1995).

Some of the researchers in Design Science consider that a sound ontology should be the foundation of this category of research.

Popper’s (1978) three worlds provide a good starting point. The three worlds are the following: World 1 is about material nature, World 2 about consciousness and mental states, and World 3 about products of human social action (Table 2.1). The third world out of three is illustrated below as one section of Table 2.1. In this section World 3,”clearly includes human artefacts, and it also covers institutions and theories”. Institutions are social constructions that have been objectified (Berger & Luckman, 1967). The world of artefacts, theories and institutions are the base during the construction of the Dashboard as described below:

Table 2.1 Popper's (1978) third world

World Explanation	Explanation	Research phenomena	Examples
World 3:	Institutions Theories Artefacts • IT artefacts • IT applications • meta IT artefacts	IT artefacts + World 3 Institutions IT artefacts + World 3 Theories IT artefacts + World 3 Artefacts	Evaluation of organizational information systems New types of theories made possible by IT artefacts Evaluation of the performance of artefacts comprising embedded computing

2.7 Dashboard and Usability

The Dashboards are a common end-user interface in today's world of web-based applications.

The design of the Dashboard is inspired by the automobile's Dashboard, because of the easy-to-read organised information. The Dashboard is designed as "a set of menus and interfaces that give the user quick access to data and information as well as simplify any editing processes they might need for a website or even an application".

(http://www.designyourway.net/blog/contact/)

Unlike current automobile Dashboards the computer Dashboard is likely to be more interactive since it is web-based.

Most Graphical User Interfaces (GUI) resemble the Dashboard concept and design. The product designers use this term or employ the metaphor of the Dashboard for the similarities which offer the end-users comfort in using the new product. [12]

[12] http://www.searchcio.techtarget.com/definition/Dashboard

Most Dashboards will represent information such “stats, analytics, schedules, messages and much more”.

As mentioned before, the interface is designed to facilitate end user interaction with the back-end of the website or an application which facilitates changes and access to information.

A nearly perfect design requires detailed research and planning in order to have an intuitive and useful interface for the end users.[13]

The Figure 2.4 illustrates a Dashboard that calculates the energy consumption for individual end users.

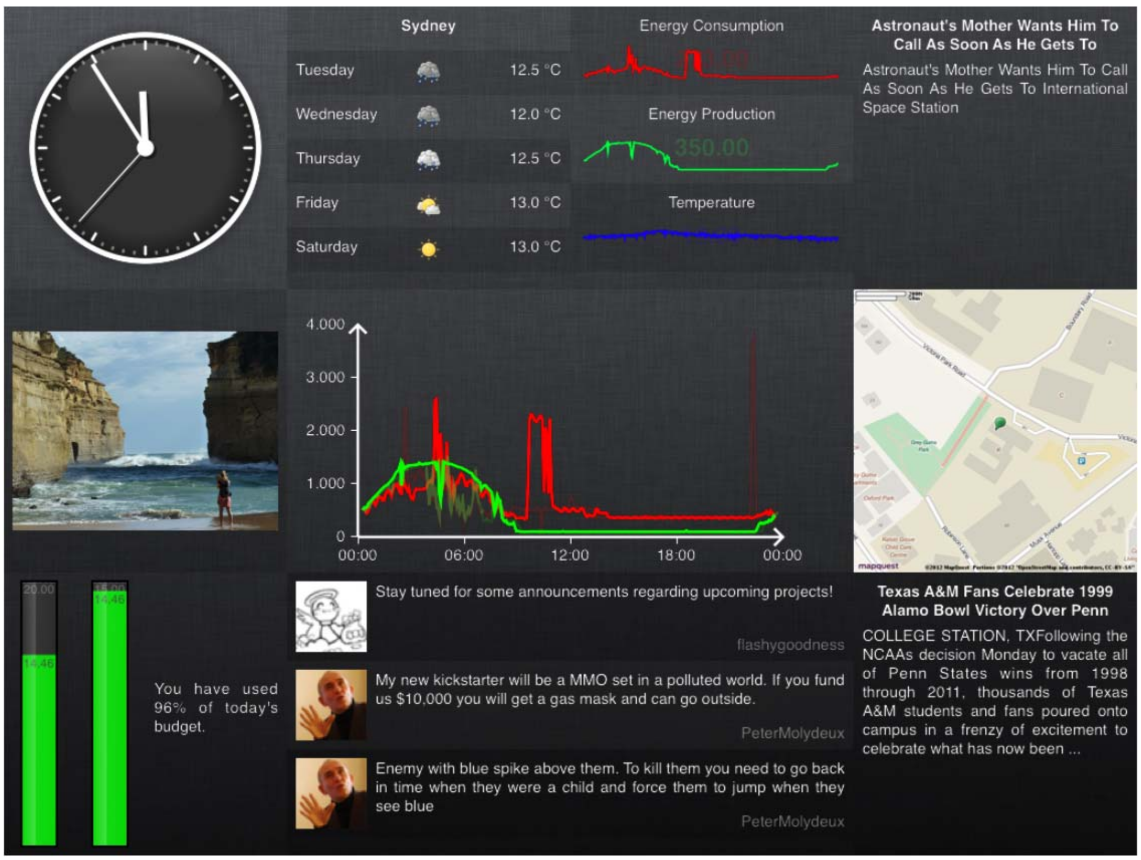


Figure 2.4. Dashboard in “view- mode” with Facebook inclusion (Filonik et al., 2013)

[13] http://www.designyourway.net/blog/contact/

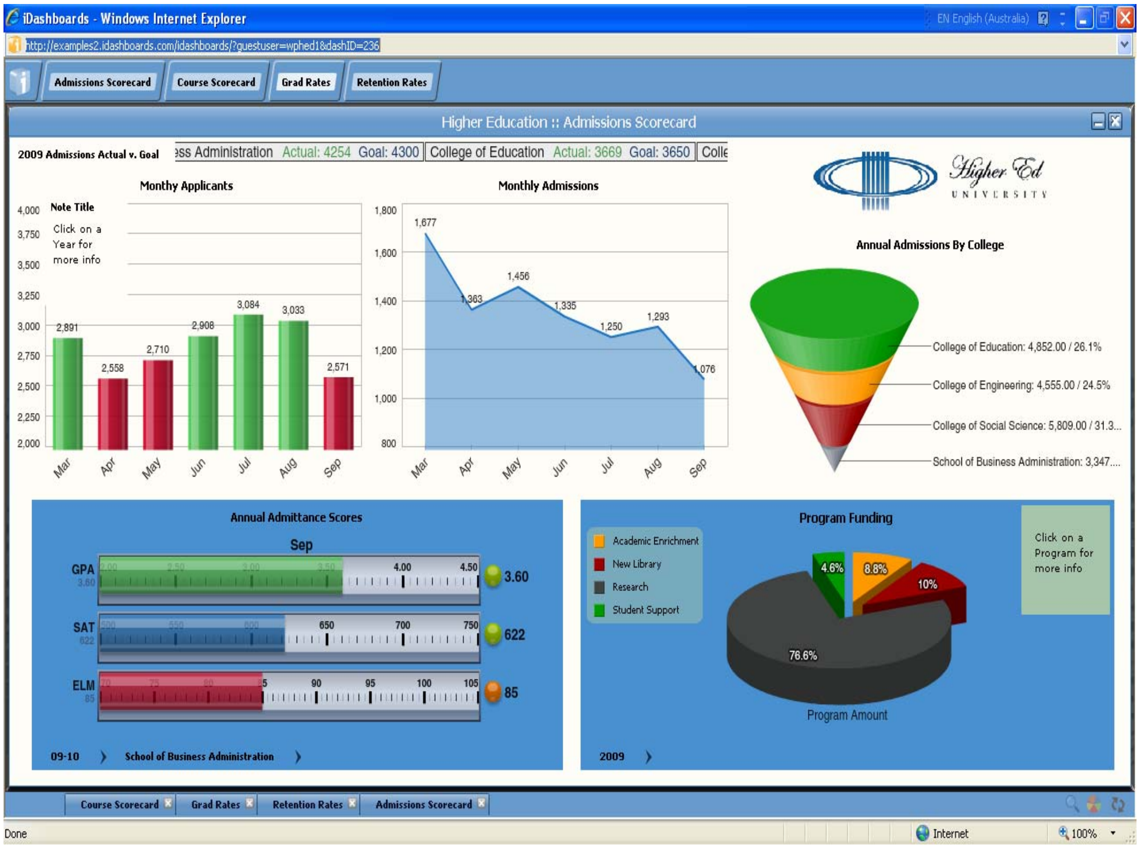


Figure 2.5. Dashboard used by the administration of a college

The implementation of the Dashboard (that can be designed based on this research) can use a Microsoft application called "Digital Dashboard technology".

This technology, according to Rees (2001), is sophisticated and comprises web-based parts/blocks, or objects, which are assembled together, run on different platforms/operating systems and use different programming languages. These objects can be utilised to design web applications which are both easy to be build and easy to use.

3 METHODOLOGY

This methodology chapter begins by formulating the research questions based on the gaps in knowledge found in the literature review. It then justifies the use of Activity Theory and Design Science to underpin the research which is designed to answer the research questions using a constructivist approach. The phases of the research plan are then described before identifying the potential for theory building in the area of Design Science.

3.1 Development of the Research Questions

The aim of the research, as stated in Chapter One, is to find a way to produce a free online application whereby SMEs can easily estimate the Environmental Footprints of the ***activities*** of their business and thus provide guidance on which of these could be realistically reduced.

The four main points that came out of the literature review concerning business activities and their Environmental Footprint are as follows:

Point 1. As identified in Section 2.2, Information Systems (IS) and Information Technology (IT) can play a crucial involvement in lowering the levels of both direct and indirect GHG emissions that result from business activities. Research in this area is inspired by the seminal article of Watson et al. (2010) who propose a new field of Energy Informatics. Here IS monitor energy use and promote methods of ensuring environmental sustainability that can be implemented by all types and sizes of enterprises. This leads to a significant reduction in energy consumption and GHG emissions that make up the Environmental Footprint of a business.

Point 2. In Australia, large firms are required to report on their direct and indirect GHG emissions and are able to dedicate resources to this task. However, determining their Environmental Footprint is difficult for SMEs although it is clear that many would like to do so in order to reduce costs and because of their concern for the future of the planet.

Point 3. Most of the literature and practical advice on reducing the Environmental Footprint of a business focuses on emissions of GHG and energy use of ***things*** (devices, machines etc.) and not on business ***activities***. Many SMEs use Carbon Calculators that can be found online

and some even have embedded such calculators on their website. Most of these calculators measure the carbon footprint of different devices, equipment, vehicles etc.

Point 4. The manager of an SME views the business as a sum of a set of activities such as production, sales, procurement etc. and not as a collection of things. It would therefore make sense to providing online applications for determining the Environmental Footprint of business activities. The manager could not only see the contribution of carrying out each of these activities in a meaningful way but could consider the benefits to the environment of choosing to use different devices, equipment and methods of conducting these activities. They can therefore measure, monitor and even change the impact that their business has on the environment in a way that is more comprehensive and meaningful.

My research plan is to identify what are the business activities that are likely to have significant Environmental Footprints in different industries and then design an Information System to determine a firm's Environmental Footprint. Based on the gap in the literature identified in Chapter 2 and outlined above the following research questions are proposed:

Q1. What are the business activities of SMEs in different industries that are likely to have a significant Environmental Footprint?

Q2. How can an online application be designed for the managers of SMEs to use for identifying and tracking the Environmental Footprint of their business's activities?

3.2 The Theoretic Basis-Activity Theory and Design Science

The focus on ***activities*** rather than ***things*** leading to Research Question 1 suggests that Activity Theory could provide a meaningful basis for this research. It has previously been shown to be popular when "developing new organizational information systems and possibly new software artefacts" (Kaplan et al., 2004). The focus on designing an information system for SMEs to track their Environmental Footprint suggests that Design Science would be useful as a theoretical basis for answering Research Question 2.

Gregor (2002) classifies the main theories used in Information Systems based on the different nature of the theories included in her taxonomy. The nature of each theory varies according to the aim of the theory, which could be explanation, analysis, prescription or prediction. Based on the main aim of each theory, the five types of theories are classified as: "(i) theory for analysing; (ii) theory for explaining, (iii) theory for predicting; (iv) theory for explaining and predicting and (v) theory for design and action" (Gregor, 2002). All five types of theories can be easily interconnected and used in different areas. In this research two theories are used, namely Activity Theory and Design Science.

The theory for analysis or "what is" (Gregor, 2002) used mostly in natural sciences as zoology, botany and biology is used for identifying, defining, observing and analysing the complex nature of phenomena and the relationships within them. In this research Activity Theory is used as a tool for identifying phenomena and activity is employed as the unit of analysis.

Theory of explaining has the aim of understanding "how" and "why" (Gregor, 2006) the things around us are constructed and are functioning. In the case of the theory of prediction, mostly used in economics, "what will be" not "how" (Gregor, 2002) is the aim of the theory. Predictions are made even if many times there are no explanations of the "how". The next type of theory presented is the theory of explaining and predicting known as EP theory using the following questions in order to explain and predict the outcomes: "why", "how" and "what will be" (Gregor, 2002). This is a common approach for both natural and social sciences. Often IS researchers feel impelled to be scientific and emulate the processes of the natural sciences. My research does not follow this way but is rather located in the social sciences.

Last but not least is the theory of design and action where "how to do" (Gregor, 2002) characterised the theory. The aim of the theory is to be a guide in giving answers when it comes to the construction of artefacts. The fifth theory known as "the theory for design and action" is eminently suited to the IS field and aptly positions my work. As Design Science belongs to this category of theories it is eminently suited as a basis for the work of this thesis. Gregor defines this type of theory as "says how to do something". The theory gives explicit

prescriptions (e.g. methods, techniques, principles of form and function) for constructing an artefact. (Gregor, 2002).

This research uses Activity Theory as an instrumental theory to explain the unit of analysis (activity) and the approach taken for the research. In particular it establishes and verifies the adoption of Design Science as a focal theory, which underpins the intellectual basis of the analysis (Davidson et al., 2012).

Some basic principles of Activity Theory and Design Science are now presented and how they are used in my research is also described.

Because it was found appropriate to focus on the Environmental Footprint of business activities, the study takes *activity* as the unit of analysis as informed by Activity Theory. Activity Theory takes a holistic perspective on how tools mediate what people do and how peoples' subjective interpretation of work leads to new tools and learning (Vygotsky 1978; Leontiev 1981). It prioritises the purpose of an activity over tools which can be changed or replaced. More recently, Engestrom (1987) introduced the concept of a "collective activity system" such as, in our case, a small business and the notion that learning occurs through contradiction within and between such activity systems. An implicit assumption about an activity is that, despite awareness of the agreed purpose of a collective activity, the actual outcomes of that activity often differ from those anticipated and that there are often unanticipated outcomes that were not foreseen.

I thus use the concept of *activity* as a holistic unit of analysis in identifying those activities of small business that have a significant Environmental Footprint such as space heating and cooling, manufacturing products and transportation. The conduct of this study follows the steps of Design Science (Peffers, et.al. 2008) and the outcomes provide new understandings of the Design Science paradigm where evaluation of the artefact provides feedback information and a better understanding of the problem in order to improve both the quality of the product and the research findings (Walls, et.al., 1992).

3.2.1 Activity Theory

This research uses *activity* as the Unit of Analysis. Activities are the main purposeful aspects of a business; what it does and why. As explained and described in more detail in the literature review of Chapter 2, Activity Theory views an activity as a cultural historical construct of what is being done while using and developing physical and cognitive tools. In

summary, the graphical representation of the socio-technical structure of an activity as created by Engestrom (1987), is shown in Figure 3.1.

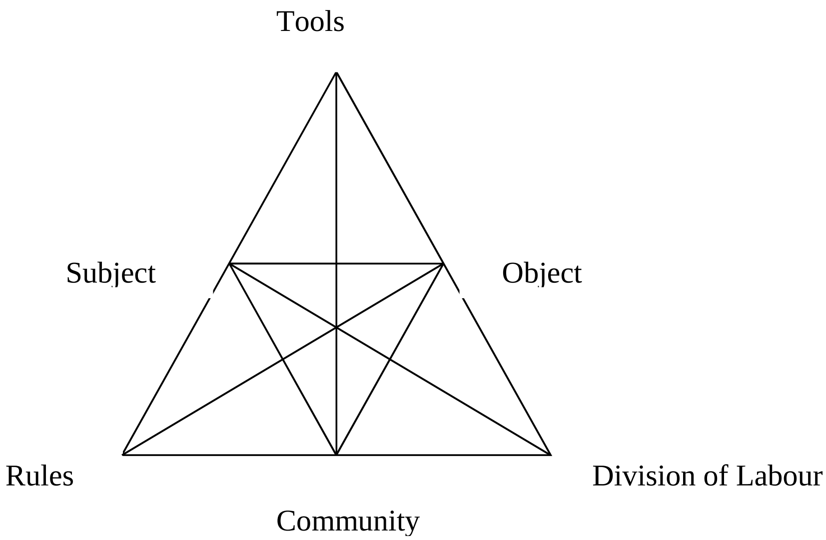


Figure 3.1. The socially distributed Activity System (Engestrom, 1987)

Activities are high-level, holistic, dynamic and purposeful representations of what people (the subjects) in business do for some purpose (the object). They are mediated by tools as well as by community in their socio-cultural context where rules and division of labour are equally important. For example, one of the main activities that is performed in a restaurant is the preparation of a meal. The physical tools used for the preparation vary (oven, grill, ingredients, utensils, etc.) and the cognitive tools include the expertise of the managers and staff. The community varies depending on the location and type of restaurant. The subjects could include professional chefs for an expensive restaurant or simple cooks for a take away business. As a consequence the Rules and the Division of Labour vary as well.

Taking the holistic approach to business activities as understood by Activity Theory is simple yet profound. It is used in this research as the framework that guides the identification of activities and the mediating tools and circumstances responsible for its Environmental Footprint.

3.2.2 Design Science

The designing process of an application, in our case a Dashboard Interface, should involve consideration of notions such as *HCI and usability*. Briefly, HCI considers the study of humans, computer technology and the interaction between them. (Dix et al, 2004). While the Usability can be defined as: "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use". (ISO, 2000).

This project was originally conceived as the relatively straightforward design of a Dashboard interface as an add-on to the working Carbon Wiki that would be filled with content and structured in such a way that extraction of data for the Dashboard would be relatively easy as described in Section 2.7. A Dashboard style of interface was chosen as the one that would be most intuitive and easy to use for busy SME managers. The end-users of the Dashboard have simultaneously the role of "producers as well as consumers of real-time data streams", considering the Wiki Crowd Source and the web based application. Paulos et al. (2011).

A particular challenge for the project was to populate the Wiki with suitable data at little cost or effort. Crowdsourcing was an obvious solution. Majchrzak and Malhotra A. (2013, p. 258) adopt the definition of crowdsourcing as: "a type of participative online activity in which an individual, an institution, a non-profit organization, or company proposes to a group of individuals of varying knowledge, heterogeneity, and number, via a flexible open call [i.e., announcement], the voluntary understanding of a task".

In order to populate the Wiki five systems development phases were carried out by students groups as follow:

1. Computer science students would install an open source version of MediaWiki the open source engine of Wikipedia on a server at the university that allowed public access, called the Carbon Wiki.
2. A second group of computer science students would design input formats to the Carbon Wiki where contributors could enter any data in the form of estimates of the emissions from business activities carried out under circumstance with which they would describe.
3. Crowdsourcing would be used to populate the Wiki led by a third group of students. The voluntary aspect of crowdsourcing was a challenge for students and unfortunately the wiki has not be well populated.

However, a major obstacle emerged when I examined the Carbon Wiki produced by the second team of computer science undergraduates and found that they had not set up suitable data structures in the wiki despite advice from myself.

The contemporary end-users are digital natives who find it easy to customise their needs to suit the web-based application or cloud deployed applications. Therefore, the design of a Dashboard interface is one of the easier elements to use considering the technological behaviour of the majority of the population. Also, the "information visualisation" according to Heikkinen**,** (2012) facilitates the usability Dashboard.

However, as already stated, a redesign of the Forms is necessary to allow input into the Wiki through crowd sourcing in order to collect data in a form suitable for use by the Dashboard. This phase of the project was not initially planned, and makes the project more interesting from a design science perspective.

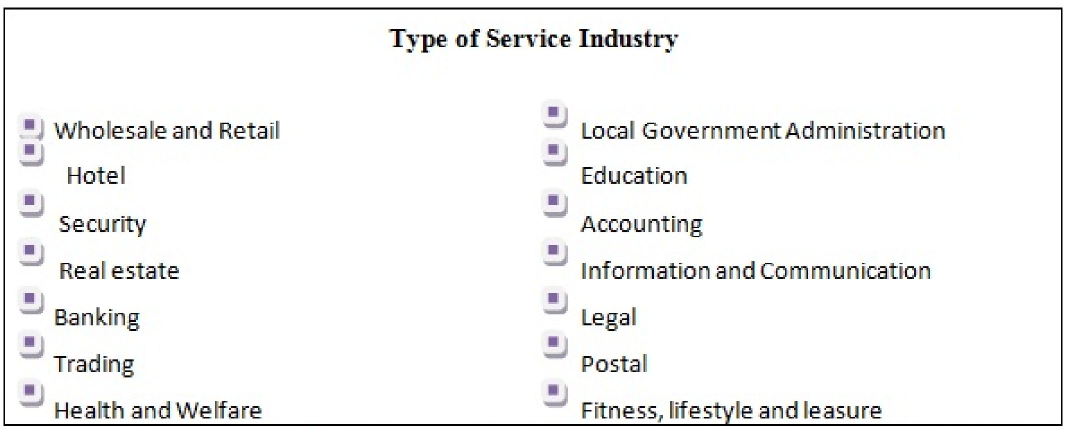


Figure 3. Screen mock up for SME users to identify their specific service. Selecting their industry will bring up a screen with the identified activities from the template for their industry. Then selecting an activity will bring up a list of entries in the Wiki that give data that people have entered on the environmental footprint of that activity.

Heating/Cooling Data

(Please, select one)

Contributor	Country	City	A/C/Heater Type	Volume	Temp.	Time	Footprint CO2e

Figure 4. Screen of the DashBoard with Data from Wiki entered from the Form of Figure 2.

Based on the description of Design Science provided in Section 2.6, the steps followed in designing the Dashboard and redesign of Wiki for Crowd Sourcing were based on those presented by Peffers, et.al (2008), and consist of following:

Identify the problem: SMEs require an end-user application to enable them to easily identify and track the environmental footprint of their business activities

Define the obstacles in reaching a solution: Initially, only problems with the Dashboard interface to the Wiki were considered. These were making it easy-to-use, low-cost and customable to be suitable to the industry of the SME. However, a major obstacle emerged, that of creating a suitable interface into the Wiki to collect data in a structured Form.

Design and (Development): Design of the input Forms, industry Templates and the end-user Dashboard.

Demonstration of the designed artefact: This became a conceptual proof of concept.

Evaluation: The findings were presented to IS experts as a conference paper and received confirmation from reviewers and participants.

Communication: Findings presented in the INSITE 2014 conference proceedings.

Details of how these steps were carried out during the four phases of the research are described below.

According to Orlikowski and Iacono (2001) the design of systems, data structures and interfaces are legitimate IS artefacts and this research designs input Forms to a Wiki and end-user Dashboard based on Templates of activities related to business activities in different industries.

3.3 Research Paradigm and Approach

Theories used for research should be consistent with the research paradigm and because of the importance placed on the way tools mediate an activity, Activity Theory and Design Science support the constructivist paradigm and approach described here. They enable the identification and description of the chosen business activities to be complete and accurate, based on the holistic nature of the theory and enable new knowledge to be created through the design of IS artefacts.

Once the topic, aim and theoretical basis of a research problem are established it is common to recognise the research paradigm within which it falls and hence the approach that should be taken. The dominant paradigms in IS are positivism and interpretivism. As a conclusion regarding the two research paradigms Gregor (2006) stated that "Interpretive research generally produces theory that is explanatory in nature. In contrast, positivist research usually aims to develop predictive theory". The positivist paradigm, therefore, is most suitable where a problem is well understood so that the research approach can be deductive and likely to involve quantitative data so that hypotheses are made and tested. It has been the dominant paradigm in IS research.

In the early years of social science research the intepretivism had an epistemological position which had origins in the interpretive ideas used by German scholars dated in the methodological writings of Max Weber (1864-1920). Later the interpretivism extended to other fields including Information Systems research.

According to Klein and Myers (1999), IS research performed according to interpretative philosophy assumes that the knowledge of individual reality is achieved, only through social constructions such as language, consciousness, shared meanings, documents, tools and other artefacts. Such research focuses on the complexity of human interpretations about the arising situation (Kaplan & Maxwell, 2005). This kind of research attempts to understand phenomena through the meanings that people attach to them (Klein & Myers, 1999). The

interpretivism based on ontological perspective has as foundation the belief that "reality is socially constructed, complex and ever-changing" Glesne (2011). According to Klein and Myers (1999) 'interpretivism philosophy assumes that the knowledge of individual reality is achieved only through social constructions such as language, consciousness, shared meanings, documents, tools and other artefacts". Also, the interpretivism paradigm suits less well-structured problems so that the approach here can be inductive with no provable hypotheses and likely to involve the analysis of qualitative data.

The problem posed in this research suits neither of these dominant paradigms. However, based on the above definitions/descriptions of interpretivism, the research has interpretive ideas as a starting point. This interpretation of ideas led to the constructivism approach and Dashboard outcome as an IS artefact. In contrast a constructivism approach is identified as the most appropriate research paradigm for this research in which findings come from what is learnt through the design of the online application for identifying and tracking the Environmental Footprint of business activities. This paradigm is consistent with use of the Design Science as theory.

The constructivist paradigm is phenomenological and, most important for this research, in IS usually involves some form of participatory action research. (Guba and Lincoln 1994). In many research papers the constructivism and positivism ontologies are irreconcilable (Cupchik, 2001). Guba and Lincoln (1994) argue that the positivism can be viewed as "naive realism", which integrates both aspects of the reality, *real* and *apprehendable.* Constructivism maintains both aspects in parallel, where understanding is created by individuals and groups. The description of the two concepts implies the existence and acceptance of the social world, "hence realism" (Cupchik, 2001). As a consequence the relationship between constructivism and phenomena can be understood as a sum of processes which take place across different worlds from physical and social to personal or self.

In the process of construction of the online application in this research many constructivist paradigm's beliefs are used. The following are enumerated as key elements: interactive link between researcher and participants, balance representation of views, raise participants' awareness, community rapport and multiple, socially constructed realities (Guba and Lincoln 1994). Lincoln and Guba (2000) concluded that the constructivist approach is based on more personal and interactive modes of data collection; a method that is heavily used in this research in order to design the interface of the online application.

In the last decade with the advent of Internet and development of information and communications technology (ICT) the constructivist approach has adapted to this new era of research and design. The process of design itself has become the new approach to research. New knowledge is created through the problems that are identified and solutions are designed and developed as a research process. As a consequence the construction of the artefacts in Information Systems is supported by the Design Research or the evolved version called Design Science Research (DSR). DSR can be used in different fields of research considering that is defined as "learning through building" (Kuechler &Vaishnavi 2008). DSR consists of activities concerned with the construction and evaluation of technology artefacts to meet organisational needs as well as the development of their associated theories.

3.4 Research Plan

In order to answer the research questions the research is structured in four Phases as presented in this section. Phase 1 involved the identification of appropriate business activities as underpinned by Activity Theory and the remainder by Design Science. As this research was undertaken part-time, there were changes that occurred in the early phases of the research that were caused by a change in circumstances beyond the researcher's control. However, as described in Chapter 5, some of these changes led to more interesting findings from the design science perspective.

Before describing the Phases in detail these changes and their implications are described.

3.4.1 Changes to the Original Research Plan

When this project was originally proposed it was designed to co-ordinate with two other projects.

One was a local government-funded organisation Business Treading Lightly (BTL) which was set up to advise local SMEs on ways to reduce their carbon footprints. They had asked for a student to interview business managers of their clients to get feedback on the success of their program and accepted me to do this while collecting data for my master's research project.

In this masters project I planned to coordinate with a group student project which would create a ***Carbon Wiki*** which would crowd source data on the Carbon Footprint of all manner

of business activities. This meant that the online application that I would produce would be a web-based Dashboard which would draw data from the Wiki so that SME end-users could easily access information in the Wiki that was relevant to their business.

By the time that I had enrolled and completed my proposal presentation the government funding for BTL had been withdrawn and the organisation had folded. As I no longer had access to their clients to interview I changed my approach to identifying business activities from an interview method to a study of the activities evident from a selection of company websites.

In addition, when it came to the phase of establishing requirements for the Dashboard, it was clear that the Forms created in the Wiki for collecting input did not collect values of suitable variables that could be used by the Dashboard to allow the end-user to make meaningful comparisons between different Wiki entries. For example, someone anywhere in the world could enter their estimate of the Carbon Footprint of the activity of heating a room in their business but only in a textbox which could use any units for the footprint and leave out vital details of details of how many degrees temperature rise this represented for what sized room over what length of time. All these details were only discernible, if at all, by reading a textual description. This was useless for the comparative purposes on the Dashboard.

As a consequence the design Phase was changed to include a complete re-design of the input Forms to the Wiki repository in order to collect data that included enough explicit information so users of the Dashboard could easily compare estimates of CO_2 equivalents (CO2e) from different activities and choose one that was similar to their circumstances.

Because of this extra work each phase was conducted as a proof of concept producing indicative designs for a selection of diverse industries but not intending to be comprehensive. This could be done for a subsequent implementation of the design.

The following Phases represent the revised Research Plan:

3.4.2 Phase 1 – Determining Business Activities [typical industries from websites]

This phase identifies typical business activities specific to different industries.

In order to identify business activity, the research uses the Activity Theory as a holistic tool and not the BPM approach in the first version of the Carbon Wiki designed by Ghose et al., (2010) which pays too much attention to low level detail.

In the initial phase of the research the business activities of different industries are determined by looking at a variety of websites of local businesses from different industries. The industries selected are: manufacturing production-steel (Blue Scope Steel) in addition to the following services: hospitality (Novotel hotel), health (Wollongong Hospital), and education (Wollongong University).

A generic list of activities that would have a substantial Environmental Footprint was produced. The list was shown to local people familiar with these businesses to verify and refine that the activities most likely to have a significant environmental impact were identified. Although these were large businesses it was assumed that the activities for each industry would be similar in SMEs.

Based on the information found, the project began by developing typical profiles of a business in each industry sector and identifying their typical regular business activities in more detail. For example, a restaurant would prepare meals, serving customers, place orders, cleaning etc. as well as office work, which meant maintaining an office. These activities would vary with the type of restaurant, and location, e.g. whether heating or air-conditioning was needed etc. The identified activities were collected in tables that classified them by scope and potential environmental impact.
As a result of this phase several industry-based Templates of activities were created.

3.4.3 Phase 2- Developing the Industry Templates

In order to design the Templates for each individual industry part of our research project Activity Theory was used an instrumental theory where activity becomes the unity of analysis. The research did not use the BPM approach of Ghose et al. (2010) to create the Templates, as this would have made the models too detailed.

The third phase of the research designed the Templates for activities which are specific for each industry. The Templates were designed to help structure the Dashboard for each type of business and support the user experience which would follow a scenario that would allow

them to select their specific business and then look for entries in the Carbon Wiki that were similar to theirs, e.g. a small restaurant in a cold/hot climate that uses electrical equipment produced from non-renewable energy supply.

The phase provides the basic items for the design of the interfaces used for crowd source and Dashboard.

3.4.3 Phase 3. – Structuring the Wiki Knowledge Repository [from Wiki]

The Carbon Wiki that would supply data for the Dashboard was designed to crowd source data on a variety of business activities was done by other colleagues and outside my control. At the end of Phase 1 it was clear that, although the Wiki contained Forms for data collection, these were not in a suitable Form to collect the data needed for the Dashboard. Therefore, in the second phase, Forms were designed for each type of business activity identified in the first Phase so that the crowd sourced end-users could enter comparable data in the Forms. Every data record would have one variable in carbon dioxide equivalents (CO2e) but different other variables depending on the activity (e.g. the room cooling Form has variables that include volume, time and temperature).

All Forms have in common the following fields: the name of the contributor, country of the contributor, the name of the city where the business is located, the date when the contributor entered the data and area field for entering any other type of information that the contributor is required to enter for the specific activity.

The resulting Forms were tested and so representative data was entered into the Wiki Knowledge Repository. This was originally out of scope for my project however I have had to design suitable input to enable the data to be accessible to the fields of the Dashboard.

3.4.4 Phase 4 - Interfaces for Dashboard for business users

This phase concerned the design of the interfaces of the Dashboard based on the Templates created in Phase 3.

The Dashboard allows the users (decision makers, employees) who have responsibility for environmental issues to measure the organisation's cost energy savings and to calculate the activities' Environmental Footprint. Any users of the Dashboard can benefit from the

interactive technologic tool in order to gain information/knowledge about the organisation's environmental position.

The Dashboard was customised for businesses in each type of industry and the particular departments and activities which are connected with the main operational processes.

One of the purposes of the Dashboard is the measurement of the different emissions that are the result of the operation activities present and specific for each type of manufacturer or service. Another purpose should be identifying patterns in usage of resources, (e.g. water, energy, fuels) therefore saving on costs or/and replacing them with more environmental sustainable alternatives. The implementation of the Dashboard could enhance the opportunities for organisations to reduce their activities' emissions and save on costs in short and/or long term.

3.5 Theory Building

As mentioned above, this research uses Activity Theory as an instrumental theory to explain the unit of analysis (activity) and establishes and verifies the adoption of Design Science as a focal theory, which underpins the intellectual basis of the analysis (Davidson et al 2012).

The original intention was to follow the steps presented by Peffers, et.al (2008) however changes were required to the straight-forward application of the steps of design science. The implication of these for Design Science, as explained in Chapter 5, lead to a process of theory building which is also informed by Activity Theory because of the contradictions between in designing the end-user Dashboard and the activities of those who first designed the Wiki for crowd sourced data collection.

4 RESULTS AND FINDINGS

In this chapter of the thesis sample outputs from each phase of the Research are used to illustrate the findings, which are then interpreted in Chapter 5.

4.1 Phase 1

As described in Section 3.4.2, this phase began by scanning the websites of local businesses from different industries, as well as identifying the generic activities that any business would have. These are listed in Table 4.1. These activities were chosen as they are not only common activities of any business, but they are also activities that would potentially contribute significantly to the Environmental Footprint according to the three main Scopes as shown in Table 4.2 to 4.6. The three Scopes are briefly defined as follow: Scope 1- emitters of different pollutants fuel, chemicals, waste management, etc), Scope 2 - indirect emissions from use of electricity and related emissions, Scope 3 - indirect emissions from third parties such as customers and suppliers.

Table 4.1 Typical Business Activities from manufacturing and service industries; to be used in the design of Templates

Generic Activities	Specific Activities
Production of Goods and Services	Manufacture goods Service Provider
Resources Storage and Transport	Procurement Transport and delivery Warehousing
ICT and Technology	Server management, networking Device lifecycle management
Administration	Maintain offices Heating and cooling
General Maintenance	Buildings and grounds maintenance Equipment servicing Vehicles fleet management Cleaning
Research and Development	Events organisation Training

Table 4.2. Scopes of polluting activities from manufacturing and service industries

Activity	Scope 1	Scope 2	Scope 3
Production Goods and Services	**YES/NO**	**YES**	**YES**
Manufacture	**YES**	**YES**	**YES**
Provide service	**YES**	**YES**	**YES**
Resource Storage and Transport			
Delivery Transport	**YES**	**YES**	**YES**
Procurement	YES	YES	YES
Transport	**NO**	**YES**	**YES**
Warehouse activities	**YES**	**YES**	**YES**
ICT			
Strategic planning	**YES**	**YES**	**NO**
Training	**NO**	**YES**	**NO**
Server management	**NO**	**YES**	**YES**
Purchasing maintaining Disposal / lifecycle	**NO**	**YES**	**NO**
Provide network /email			
Create maintain Website			
Administration			
Payroll	**NO**	**YES**	
HR	**NO**	**YES**	
CRM	**YES**	**YES**	
Accounts			
Maintenance			
Buildings and grounds	**YES**	**YES**	NO
Equipment	**YES**	**YES**	NO
Trucks, cars, vans	**YES**	**YES**	NO
Security	**YES**	**NO**	**YES**
Cleaning	**YES**	**YES**	**YES**
Heating and Cooling	**YES**	**YES**	**YES**
Catering	**YES**	**YES**	**YES**
Research and Development	**YES**	**YES**	**YES**
Research	**YES**	**YES**	**YES**
Workshop	**NO**	**YES**	**YES**
Conferences	**YES**	**YES**	**YES**
Marketing	**YES**	**YES**	**YES**
Event organisation	**NO**	**YES**	**YES**

The general activities shown in Tables 4.1 and 4.2 were further examined on suitable websites and the list customised for each industry.

Tables 4.3 to 4.6 illustrate samples of specific activities for each industry - manufacturing and service. As mentioned the information is provided from websites of specific companies.

The manufacturing company is BHP Billiton with historical connections to the Illawarra with the following URL http://www.bhpbilliton.com/home/Pages/default.aspx and the two service-provider companies: University of Wollongong (UOW) with the URL http://www.uow.edu.au/index.html and Marketview Hotel located in Wollongong and owned by UOW with its http://www.marketviewaccommodation.com.au/.

Table 4.3. Activities of production of goods and services in a manufacturing and hotel service organisations

Activity	Scope 1	Scope 2	Scope 3	Chemicals & Waste	Water
Production Goods					
Minerals exploration activities	**YES**	**YES**	**YES**	**YES**	**YES**
Resources production activities	**YES**	**YES**	**YES**	**YES**	**YES**
Production Services					
Delivering transport	**YES**	**YES**	**NO**	**NO**	**NO**
Travel (meetings, conferences, etc.)	**NO**	**YES**	**YES**	**NO**	**NO**
Travel(staff and students commuting to university, students going home, etc)	**YES**	**YES**	**YES**	**YES**	**YES**

Table 4. 4 Activities from a steelworks manufacturing- industry

Activity	Scope 1	Scope 2	Scope 3	Chemicals and Waste	Water usage
Production Goods					
Coated and Industrial Products	**YES**	**YES**	**YES**	**YES**	**YES**
Resource Storage and Transport					
Delivering transport	**YES**	**YES**	**NO**	**YES**	**NO**
Travel (meetings, conferences, etc.)	**NO**	**YES**	**YES**	**YES**	**NO**
Procurement	**YES**	**YES**	**YES**	**YES**	**YES**
Warehouse activities (ITC, admin., maintenance)	**YES**	**YES**	**YES**	**YES**	**YES**
ICT					
Servers :management (changes, repairs, etc..)	**YES**	**YES**	**NO**	**YES Waste**	**YES**
Desktops: helpdesk, maintenance	**NO**	**YES**	**NO**	**YES e-Waste**	**NO**
Networks: maintenance, security	**NO**	**YES**	**YES**	**YES e-Waste**	**NO**
printers, scanners, whiteboards, projectors, etc (maintenance)	**NO**	**YES**	**NO**	**YES e-Waste**	**NO**
Applications: installation and maintenance				**YES e-Waste**	
Data centres: operations and management		**YES**		**YES**	
ITC suppliers				**YES**	
Administration					
Payroll	**YES**	**YES**	**NO**	**YES**	**YES**
HR	**YES**	**YES**	**YES**	**YES**	**YES**
CRM	**YES**	**YES**	**YES**	**YES**	**YES**
Accounts	**YES**	**YES**	**YES**	**YES**	**YES**
Maintenance					
Buildings and grounds	**YES**	**YES**	**NO**	**YES**	**YES**
Equipment	**YES**	**NO**	**NO**	**YES**	**YES**
Trucks, cars, vans	**YES**	**YES**	NO	**YES**	**YES**
Security	**YES**	**YES**	**NO**	**YES**	**NO**
Cleaning	**YES**	**YES**	**YES**	**YESe**	**YES**
Catering	**YES**	**YES**	**NO**	**YES**	**YES**
Research and Development					
E-training (data centres-energy intensive users)	**YES**	**YES**	**YES**	**YES**	**YES**
Face-to-face training	**YES**	**YES**	**YES**	**YES**	**YES**

Marketing					
Sales	**YES**	**NO**	**YES**	**YES**	**NO**

Table 4. 5 Sample of Activities from services-hospitality industry,

Activity	Scope 1	Scope 2	Scope 3	Chemicals & Waste	Water
Production Services					
Bookings	**NO**	**YES**	**YES**	**YES**	**YES**
Room service	**YES**	**YES**	**YES**	**YES**	**YES**
Transport from and to airport	**YES**	**YES**	**YES**	**YES**	**YES**
Resource Storage and Transport					
Delivering transport	**YES**	**YES**	**NO**	**YES**	**YES**
Travel (meetings, conferences, etc.)	**NO**	**YES**	**YES**	**YES**	**YES**
Procurement	**YES**	**YES**	**YES**	**YES**	**YES**
ICT					
Servers :management (changes, repairs, etc.)	**YES**	**YES**	**YES**	**YES Waste**	**YES**
Desktops: helpdesk ,maintenance	**YES**	**YES**	**YES**	**YES e-Waste**	**NO**
Networks: maintenance, security	**YES**	**YES**	**YES**	**YES e-Waste**	**NO**
printers ,scanners, whiteboards, projectors, etc. (maintenance)	**YES**	**YES**	**YES**	**YES e-Waste**	**NO**
Applications: installation and maintenance	**YES**	**YES**	**YES**	**YES e-Waste**	**NO**
ITC suppliers					
Administration					
payroll	**NO**	**YES**	**NO**	**YES**	**YES**
HR	**NO**	**YES**	**NO**	**YES**	**YES**
CRM	**YES**	**YES**	**NO**	**YES**	**YES**
Accounts	**YES**	**YES**	**NO**	**YES**	**YES**
Maintenance					
Buildings and grounds	**YES**	**YES**	**YES**	**YES**	**YES**
Equipment	**YES**	**YES**	**YES**	**YES**	**YES**
Trucks, cars, vans	**YES**	**YES**	**YES**	**YES**	**YES**
Security	**YES**	**YES**	**YES**	**YES**	**YES**
Cleaning	**YES**	**YES**	**YES**	**YES**	**YES**
Heating and Cooling	**YES**	**YES**	**YES**	**YES**	**YES**
Kitchen	**YES**	**YES**	**YES**	**YES**	**YES**
Staff Development	**YES**	**YES**	**NO**	**YES**	**YES**
E-training (data centres-energy intensive users)	**YES**	**YES**	**YES**	**YES**	**YES**
Face-to-face training	**NO**	**YES**	**YES**	**YES**	**YES**

Conferences, seminars	**YES**	**YES**	**YES**	**YES**	**YES**
Marketing	**NO**	**YES**	**YES**	**YES**	**NO**

Table 4. 6 Example of Activities from services-education industry

Activity	Scope 1	Scope 2	Scope 3	Ch. and Waste	Water
Production Services					
Teaching and learning Lectures, tutorials and workshops, Video conferences (student)	**YES**	**YES**	**YES**	**YES**	**YES**
Laboratory classes (student)					
e-learning (student) Workshops, video conferences, training (academic staff)					
Preparation of classes					
Resource Storage and Transport					
Delivering transport	**YES**	**YES**	**NO**	**NO**	**NO**
Travel (meetings, conferences, etc.)	**NO**	**YES**	**YES**	**NO**	**NO**
Procurement	**YES**	**YES**	**YES**	**YES**	**YES**
Travel (staff and students commuting to university, students going home, etc)	**YES**	**YES**	**YES**	**YES**	**NO**
ICT					
Servers :management (changes, repairs, etc.)	**YES**	**YES**	**YES**	**YES Waste**	**YES**
Desktops: helpdesk, maintenance	**YES**	**YES**	**YES**	**YES e-Waste**	**NO**
Networks: maintenance, security	**YES**	**YES**	**YES**	**YES e-Waste**	**YES**
printers, scanners, whiteboards, projectors, etc (maintenance)	**YES**	**YES**	**YES**	**YES e-Waste**	**NO**
Applications: installation and maintenance	**YES**	**YES**	**YES**	**YES Waste**	**NO**
Data centres: management	**YES**	**YES**	**YES**	**YES e-Waste**	**YES**
ITC suppliers					
Administration					
Payroll	**NO**	**YES**	**NO**	**YES**	**YES**
HR	**NO**	**YES**	**NO**	**YES**	**YES**
CRM	**YES**	**YES**	**NO**	**YES**	**YES**
Accounts	**YES**	**YES**	**NO**	**YES**	**YES**
Accommodation	**YES**	**YES**	**YES**	**yes**	**yes**

Enrolments (Pre-application Application, Pre-registration, Registration, Induction)	**YES**	**YES**	**YES**	**YES**	**YES**
Pastoral care	**NO**	**YES**	**YES**	**NO**	**NO**
Graduation; printing, catering, retail, parking, training	**YES**	**YES**	**YES**	**YES**	**YES**
Alumni processes: social events, Advertising	**YES**	**YES**	**YES**	**YES**	**YES**
Employability and careers services: Advertising, meetings, workshops	**YES**	**YES**	**YES**	**YES**	**YES**
Maintenance					
Buildings and grounds	**YES**	**YES**	**NO**	**YES**	**YES**
Equipment	**YES**	**YES**	**NO**	**YES**	**YES**
Trucks, cars, vans	**YES**	**YES**	**NO**	**YES**	**YES**
Security	**YES**	**NO**	**YES**	**YES**	**NO**
Biodiversity	**YES**	**YES**	**YES**	**YES**	**YES**
Cleaning	YES	YES	YES	YES	
Heating and Cooling	**YES**	**YES**	**YES**	**YES**	**YES**
Catering					
Sustainable food (organic and seasonal raw material used, not bottled water, etc)	**NO**	**YES**	**YES**	**YES**	**YES**
Research and Development	**YES**	**YES**	**NO**	**YES**	
E-training (data centres-energy intensive users)	**YES**	**YES**	**YES**	**YES**	**YES**
Face-to-face training	**NO**	**YES**	**YES**	**YES**	**YES**
Conferences	**YES**	**YES**			
Seminars	**YES**	**YES**			
Data research centres: storage of records	**YES**	**YES**	YES	YES	YES
Marketing	**NO**	**YES**	**YES**		

Table 4.2-4.6 are indicative only and do not take account of all possible factors such as: water consumption, reusability and disposal, type of fuel consumption, waste of any material as a result of polluting activities, in services-education industry.

4.2 Phase 2

As described in Section 3.4.3, Templates for each industry were designed based on the outcomes on Phase 1. The results of this phase are crystallized in a series of Templates which were created in a simple Format that could be used to design the interfaces/screens of the Dashboard for each type of industry and its activities, after the data is entered in the Forms. Figures 4.5 and 4.6 are examples of different Templates.

Activities

Administration

a. Heating
b. Cooling
c. Running an office

Building and grounds Maintenance

a. Waste management
b. Water usage management
c. Grounds service(lawns, gardens, ponds ,fauna and flora if applicable)
d. Building maintenance
e. Cleaning

Transport

a. Suppling(in/out)
b. Delivering(in/out)

Kitchen

a. Cooking
b. Preparation
c. Cleaning
d. Maintenance

Figure 4.5 An example of a template that helps the end user to identify their specific activities in the hospitality industry that may contribute to their environmental footprint.

Activity	Subject (who does it)	Object	Tools	Environmental footprint
Heating	Maintenance people	Keep room at good temperature	Heating system	Scope 2, emissions through use of energy
Cooling	Maintenance people	Keep room at good temperature	Cooling system	Scope 2, emissions through use of energy

Running an office	Administration staff	Performing administrative tasks	Office equipment	Scope 2, emissions through use of energy
Suppling	Suppling people	Suppling goods	Transport	Scope1, emission through use of petrol, Scope 3, indirect emissions of GHG
Delivering	Delivering people	Delivering goods	Transport	Scope1, emission of GHG through use of petrol, Scope3, indirect emissions of GHG
Cooking	Chefs	Cooking meals	Cooking equipment	Scope 2, emissions through use of energy
Preparation	Kitchen staff	Preparation for cooking meals	Preparation equipment	Scope 2, emissions through use of energy
Cleaning	Cleaning staff	Cleaning equipment and kitchen	Cleaning products	Scope 2, emissions through use of energy, Scope1, direct emissions of GHG
Maintenance	Maintenance people	Maintaining equipment	Maintenance products and equipment	Scope 2, emissions through use of energy, Scope1, direct emissions of GHG through use of petrol
Waste management	Maintenance people	Manage the waste produce	Waste management equipment	Scope 2, emissions through use of energy, Scope 3, indirect emissions of GHG
Water usage management	Maintenance people	Manage the water use for different activities	Water usage management equipment	Scope 2, emissions through use of energy
Grounds service	Maintenance people	Maintaining the grounds	Maintenance products and equipment	Scope 2, emissions through use of energy, Scope1, emissions through use of petrol
Building maintenance	Maintenance people	Maintaining the building	Maintenance products and equipment	Scope 2, emissions through use of energy, Scope1, emissions through use of petrol

Table 4.2 Illustrates details of specific activities in the hospitality industry that may contribute to their environmental footprint.

Activities

Plant

a. Water Use

b. Cooling

c. Heating

Building and Grounds Maintenance

a. Waste (outsourced, in house)

b. Water usage (type of storage)

c. Grounds service (lawns, gardens, ponds, fauna and flora if applicable)

d. Building maintenance (outsourced trading companies, cooling, heating, in house maintenance services)

Warehouse

a. Cooling

b. Heating

Cleaning

a. Type of cleaning products (ex. environmental friendly)

b. Water usage

d. Types of equipment

Transport

a. Supplying (in/out)

b. Delivering (in/out)

c. Type of vehicle

d. Type of fuel

Information and Communication

a. Cooling

b. Heating

c. Data centres

d. Type of equipment

Administration

a. Cooling

b. Heating

c. Type of equipment (eg. energy saving)

Figure 4.6. A sample of a template that helps the end user to identify their specific activities in the manufacturing industry that may contribute to their environmental footprint.

Activity	Subject (who does it)	Object	Tools	Environmental footprint
Water usage	Maintenance people	Manage the water use for different activities	Water usage management equipment	Scope 2, emissions through use of energy
Cooling	Maintenance people	Keep plant rooms at good temperature	Cooling system	Scope 2, emissions through use of energy
Heating	Maintenance people	Keep plant rooms at good temperature	Heating system	Scope 2, emissions through use of energy
Waste	Maintenance people	Manage the waste produce	Waste management equipment	Scope 2, emissions through use of energy, Scope 3, indirect emissions of GHG
Ground service	Maintenance people	Maintaining the grounds	Maintenance products and equipment	Scope 2, emissions through use of energy, Scope1, emissions of GHG through use of petrol
Building maintenance	Maintenance people	Maintaining the building	Maintenance products and equipment	Scope 2, emissions through use of energy, Scope1, emissions of GHG through use of petrol

Table 4.3 Illustrates details of specific activities in the manufacturing industry that may contribute to their environmental footprint.

Activities

Teaching and Learning Services

a. Lectures, tutorials and workshops, video conferences (student)

b. Laboratory classes (student)

c. e-learning(student)

d. Workshops, video conferences, training (academic staff)

e. Preparation of classes

Resource Storage and Transport

a. Delivering transport
b. Travel (staff and students commuting to meetings, conferences, fields trips, etc.)

c. Procurement
d. Travel (staff and students commuting to university, students going home, etc)

ICT

a. Servers: management (changes, repairs, etc.)

b .Desktops: helpdesk, maintenance

c. Networks: maintenance, security

d. Printers, scanners, whiteboards, projectors, etc (maintenance)

e. Applications: implementation and maintenance

f. Data centres: management

g. ITC suppliers

Administration

a. Payroll

b. HR

c. CRM

d. Accounts
e. Enrolments(Pre-application ,Application ,Pre-registration, Registration, Induction)
f. Pastoral care
g. Graduation: printing, catering, retail, parking, training alumni processes: social
h. Events, advertising
I. Employability and careers services: advertising, meetings, workshops

Maintenance

a. Buildings and grounds

b. Equipment

c. Trucks, cars, vans

d. Security

e. Biodiversity

f. Cleaning

Heating and Cooling
a. Venues that belong to the educational institution

Catering
a. Sustainable food (organic and seasonal raw material used, not bottled water, etc)

Research and Development

a. E-training (data centres-energy intensive users)

b .Face-to-face training

c. Conferences

d. Seminars

e. Data research centres: storage of records

Marketing

Activity	Subject (who does it)	Object	Tools	Environmental footprint
Cooling	Maintenance people	Keep warehouse at good temperature	Cooling system	Scope 2, emissions through use of energy
Heating	Maintenance people	Keep plant warehouse at good temperature	Heating system	Scope 2, emissions through use of energy

Activity	Subject (who does it)	Object	Tools	Environmental footprint
Suppling (in/out)	Suppling people	Suppling goods	Transport	Scope1, emission through use of petrol, Scope 3, indirect emissions of GHG
Delivering (in/out)	Delivering people	Delivering goods	Transport	Scope1, emission through use of petrol, Scope3, indirect emissions of GHG
Type of vehicle	Drivers	Vehicles use in transport	Vehicles (trucks, vans, hybrid, etc.)	Scope1, emission through use of different fuels
Type of fuel	Drivers	Fuels use in transport	Fuels (petrol, diesel, etc.)	Scope1, emission through use of different fuels
Activity	Subject (who does it)	Object	Tools	Environmental footprint
Cooling	Maintenance people	Keep administration rooms at good temperature	Cooling system	Scope 2, emissions through use of energy

Heating	Maintenance people	Keep administration rooms at good temperature	Heating system	Scope 2, emissions through use of energy
Type of equipment	Administrative staff	Administrative tasks	Administrative equipment	Scope 2, emissions through use of energy
Activity	Subject (who does it)	Object	Tools	Environmental footprint
Cooling	Maintenance people	Keep rooms and equipment at good temperature	Cooling system	Scope 2, emissions through use of energy
Heating	Maintenance people	Keep rooms and equipment at good temperature	Heating system	Scope 2, emissions through use of energy
Data Centres	Maintenance people	Keep data centres in good conditions	Data Centres equipment	Scope 2, emissions through use of energy, Scope 3, indirect emissions of GHG
Type of equipment	ICT staff	ICT tasks	ICT equipment	Scope 2, emissions through use of energy
Activity	Subject (who does it)	Object	Tools	Environmental footprint
Teaching and Learning services (lectures, laboratory, e-learning, etc.)	Teaching and Learning staff	Delivering teaching and Learning services	Teaching and Learning applications and equipment	Scope 2, emissions through use of energy
Resource Storage and Transport (delivering, travel, procurement)	Resource Storage and Transport staff	Keep resources well stored and providing necessary products and equipment for a good running of	Resource Storage and Transport equipment	Scope 2, emissions through use of energy

		services		
ICT (network, desktops, laptops, data centres, servers, etc.)	ICT staff	Keep ICT products and equipment in good conditions	ICT equipment	Scope 2, emissions through use of energy, Scope 3, indirect emissions of GHG
Administration	Administration staff	Administration tasks	Administration products and equipment	Scope 2, emissions through use of energy
Maintenance	Maintenance staff	Maintenance services	Maintenance products and equipment	Scope1, direct emissions of GHG, Scope 2, emissions through use of energy, Scope 3, indirect emissions of GHG
Heating and Cooling	Maintenance staff	Keep venues at good temperature	Heating and Cooling equipment	Scope 2, emissions through use of energy
Catering	Catering staff	Providing catering services to staff and students	Catering products and equipment	Scope 2, emissions through use of energy, Scope 3, indirect emissions of GHG
Research and Development	Research and Development staff	Research and Development services	Research and Development products and equipment	Scope 2, emissions through use of energy, Scope 3, indirect emissions of GHG
Marketing	Marketing staff	Marketing services	Marketing products and equipment	Scope 2, emissions through use of energy, Scope 3, indirect emissions of GHG

Table 4.4 Illustrates details of specific activities in the education industry that may contribute to their environmental footprint.

4.3 Phase 3

As described in Section 3.4.4, this phase had to be added to the original research design when shortcomings were identified in the Carbon Wiki created by our colleagues to collect data via crowd sourcing. Its structure did not match the business activities identified in Phase 1 and did not provide sufficient detail for manipulation by the desired Dashboard interface. As a substantial component of the research, Forms were designed and implemented in the Carbon Wiki.

Forms were created for this project: air-conditioning, running office, space heating, transport, water heating, procurement, data centre, network, cooking, room cleaning, catering etc. Figures 4.6 to 4.9 are presented as examples.

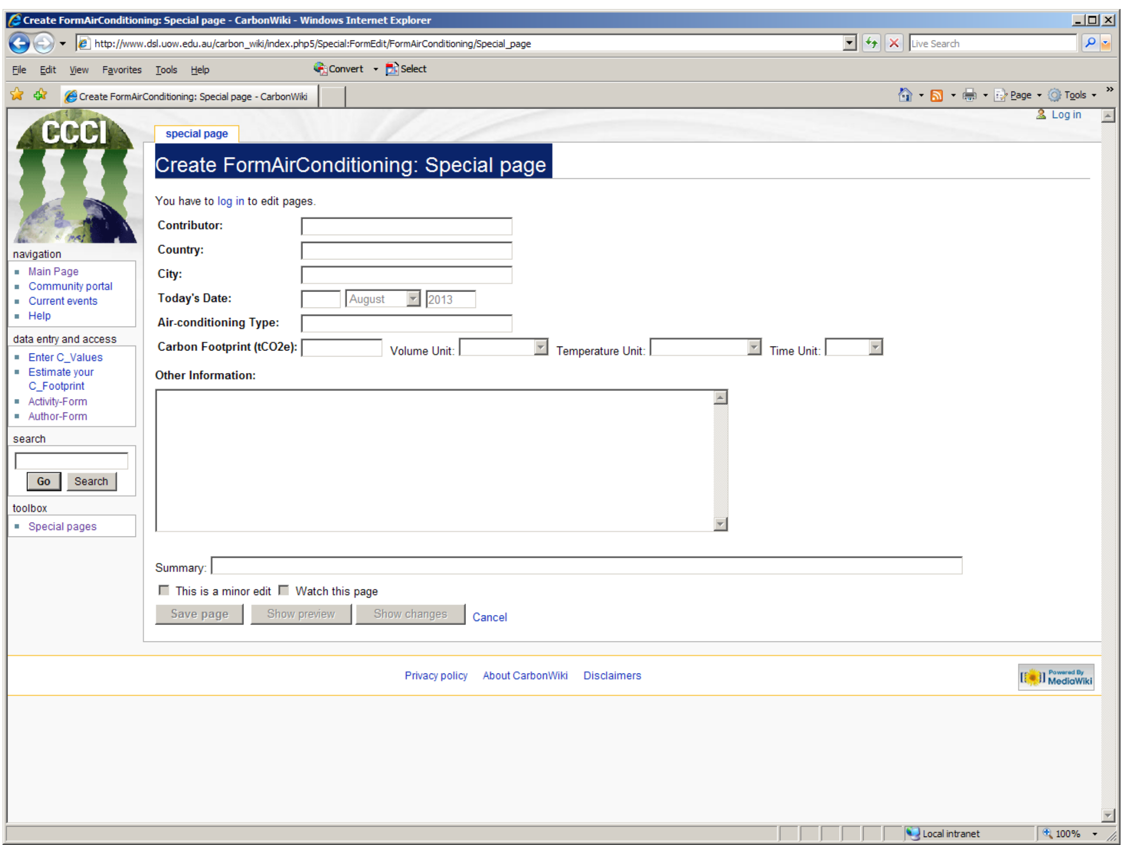


Figure 4.6. Form used to collect data for further calculation of the environmental footprint from cooling/heating spaces. Note that the user must enter a value of Co2e for a given volume, for a specific temperature rise and for a specified time.

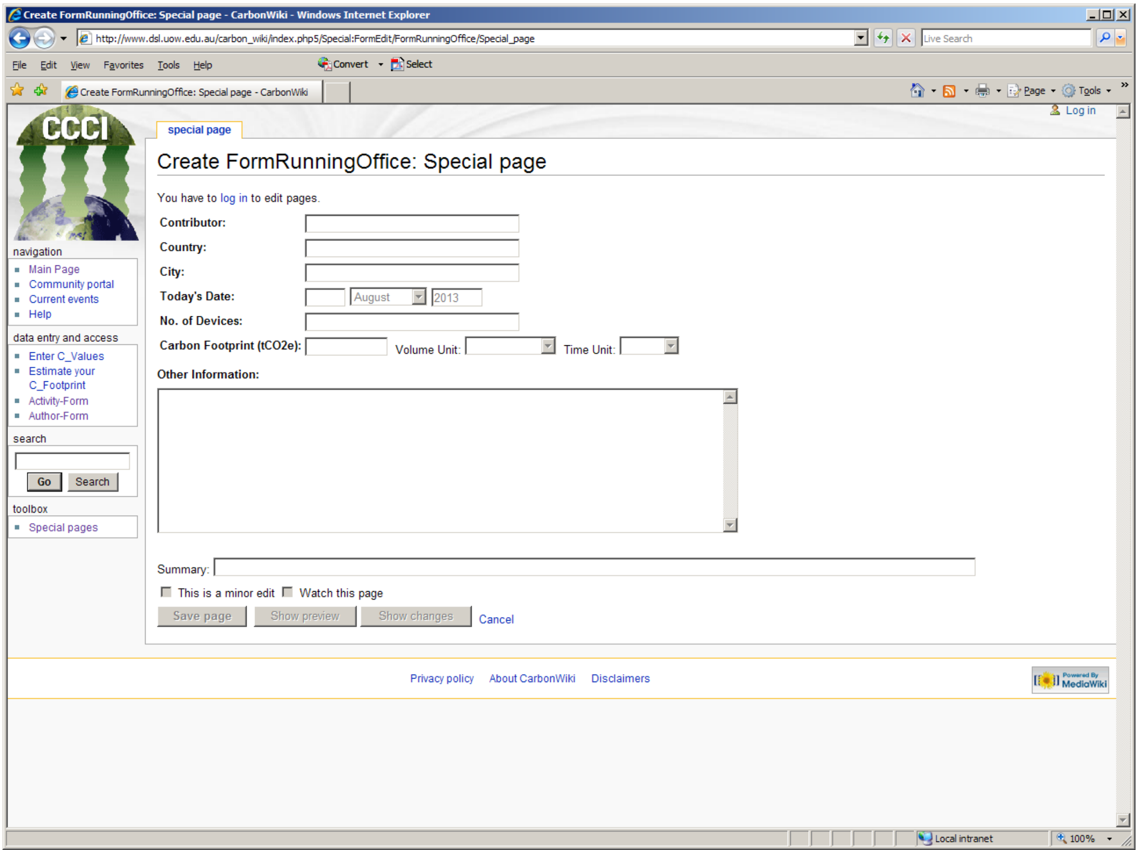


Figure 4.7. Form used to collect data for further calculation of CF from running office spaces. Note that the user must enter a value of Co2e for a given volume, for a specific temperature rise and for a specified time, also number of devices in use.

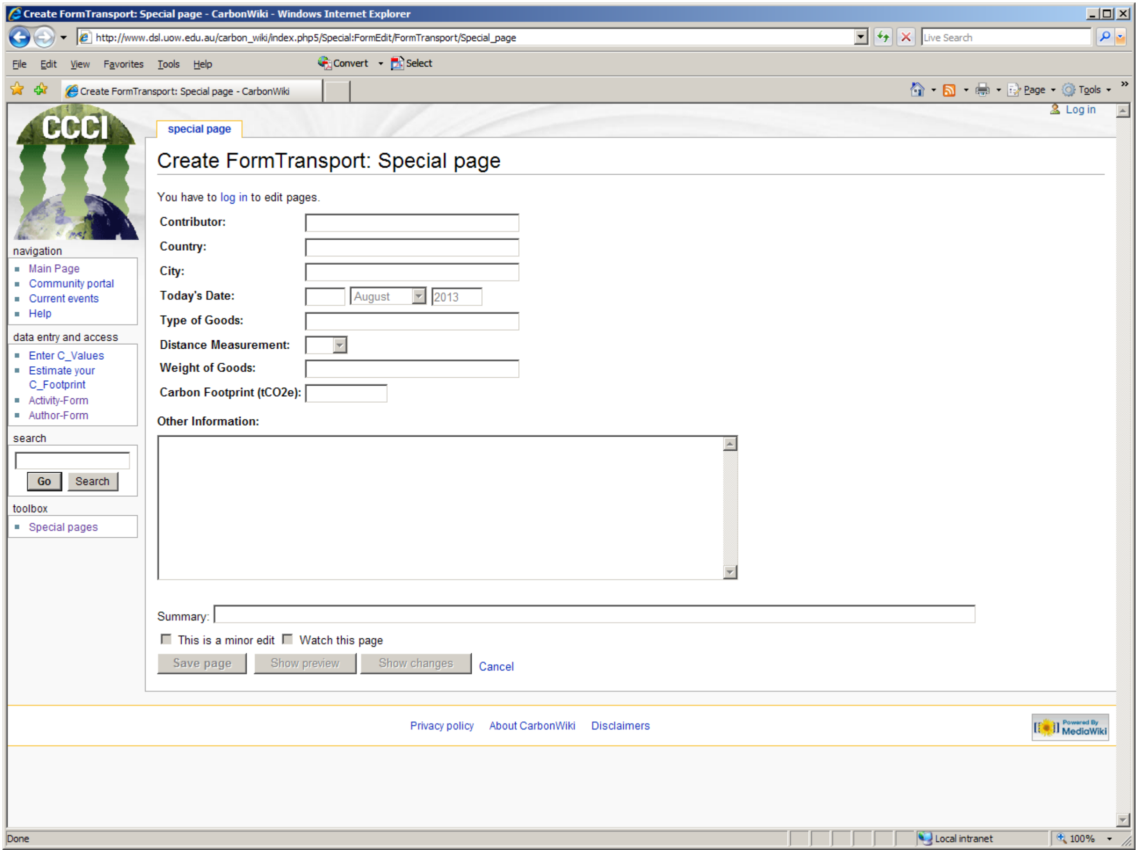


Figure 4.8. Form used to collect data for further calculation of CF from transportation activities. Note that the user must enter a value of Co2e for a distance travelled, for a specific weight of goods transported, for a specified type of goods and type of vehicle used.

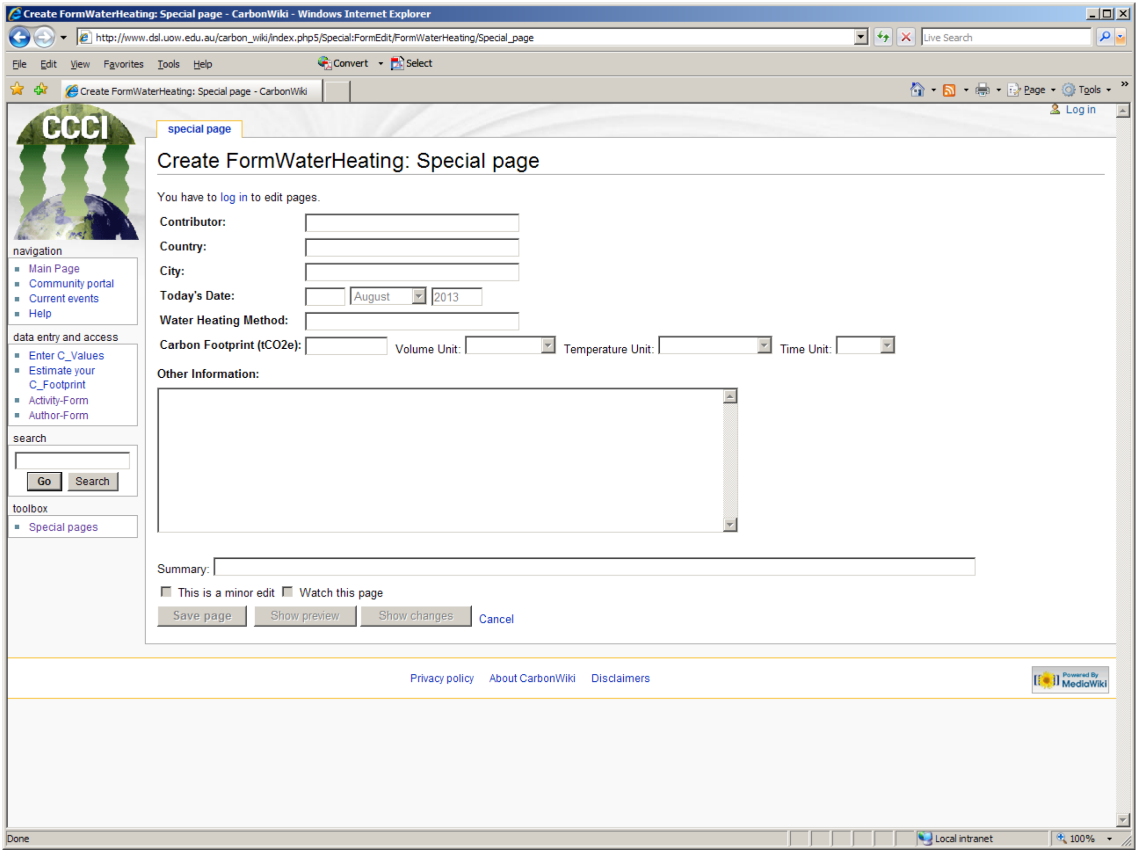


Figure 4.9. Form used to collect data for further calculation of CF from running office spaces. Note that the user must enter a value of Co2e for a given volume, for a specific temperature rise and for a specified time, also the water heating method used.

4.4 Phase 4

As described in Section 3.4.5, in this phase Dashboard screens were designed, as was the navigation between them.

In the Dashboards a user would first choose their industry from those in Figure 3. They would then select activities from a screen designed from the Template in Figure 2. Then they would be presented with Wiki entries (in the Format of Figure 4) that would correspond to these from which they could select the ones most appropriate to their circumstances.

Type of Service Industry

- Wholesale and Retail
- Hotel
- Security
- Real estate
- Banking
- Trading
- Health and Welfare
- Local Government Administration
- Education
- Accounting
- Information and Communication
- Legal
- Postal
- Fitness, lifestyle and leasure

Figure 4.10. Screen mock-up for SME users to identify specific service industry. Selecting their industry will bring up a screen with sample activities from the template for their industry. Then selecting an activity will bring up a list of entities in the Wiki that give data that people have entered on the Environmental Footprint of that activity.

Select Type of Manufacturing Industry

- Metal and Associated Industries
- Automotive and Rail
- Chemical
- Food, Beverages, Tobacco
- Agriculture and Wool
- Clothing and Textile
- Machinery and Equipment
- Wood and Paper
- Mining
- Aircraft
- Furnishing

Figure 4.11. Screen mock-up for SME users to identify their specific manufacturer. Selecting their industry will bring up a screen with the identified activities from the template for their industry. Then selecting an activity will bring up a list of entries in the Wiki that give data that people have entered of the environmental footprint of that activity.

Heating/Cooling Data
(Please, select one)

Contributor	Country	City	A/C/Heater Type	Volume	Temp.	Time	Footprint CO2e

Figure 4.12 Screen of the Dashboard with data from Wiki entered from the Form of Figure 4.6

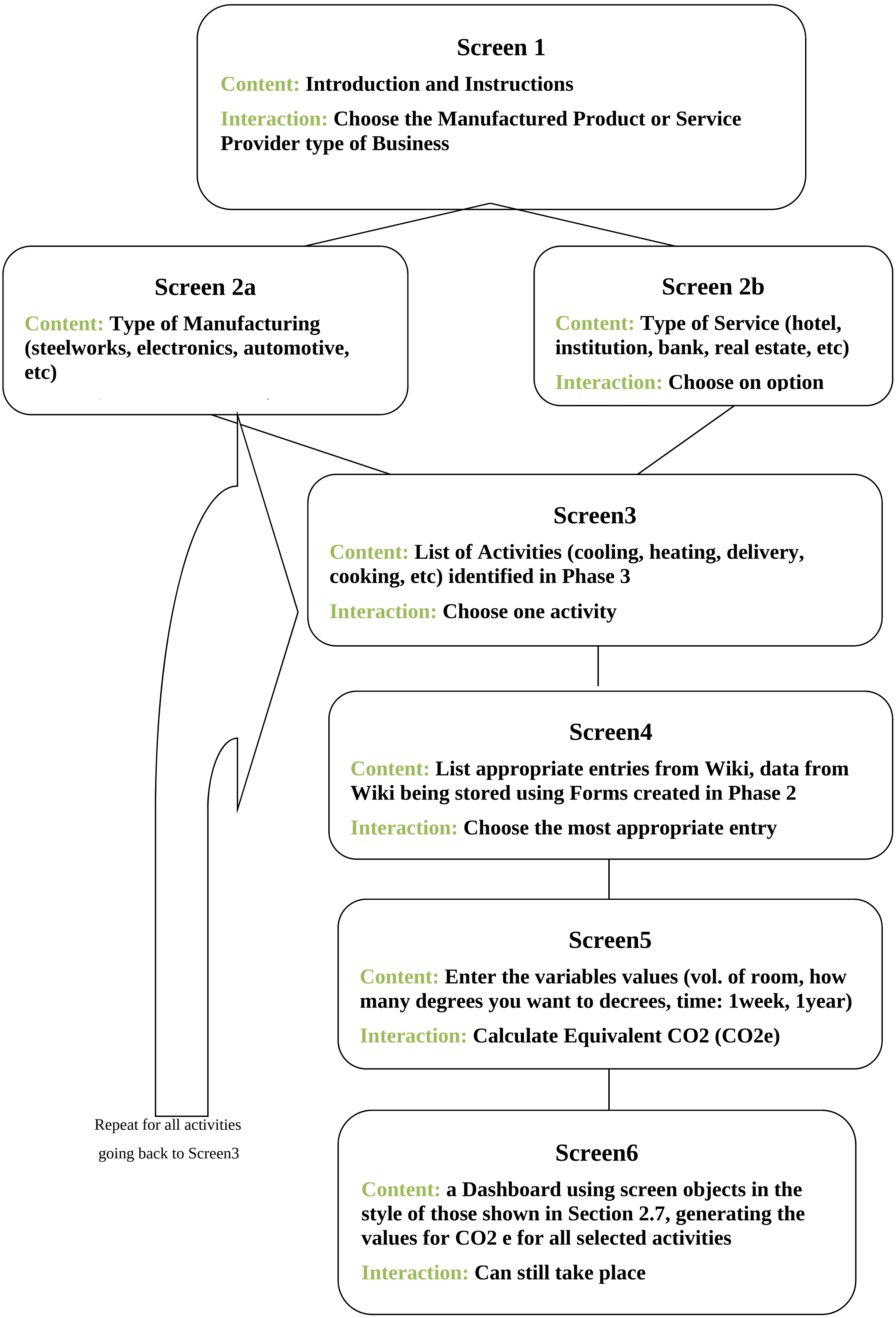
4.4 Scenarios of use of the Dashboard/Dashboard Navigation

There is a succession of screens that the users will navigate in order to obtain the calculation of CO2 emissions for the appropriate activities in their business.

In the section below is offered a basic representation of these screens with their content and interaction.

A scenario from the hospitality service industry, a small takeaway business where the manager decides to use the Dashboard in order to calculate the Environmental Footprint of its business activities is presented. He/she will follow the instructions displayed on the ordered screens.

At screen No.3 one activity can be chosen at a time, for instance cooling the shop, and then he/she will choose the most appropriate entry from the Wiki repository. After that step, the variables, e.g. volume of the room, temperature, duration of cooling, type of AC are entered and the calculation of CO2e is made. The last screen is a display offered for all selected activities on the Dashboard interface. Also, the manager has the option to choose the type of energy used, such as carbon base or renewable, considering that the shop can have solar panels installed.


Screen 1
Content: Introduction and Instructions
Interaction: Choose the Manufactured Product or Service Provider type of Business
Screen 2a
Content: Type of Manufacturing (steelworks, electronics, automotive, etc)
Screen 2b
Content: Type of Service (hotel, institution, bank, real estate, etc)
Interaction: Choose on option
Screen3
Content: List of Activities (cooling, heating, delivery, cooking, etc) identified in Phase 3
Interaction: Choose one activity
Screen4
Content: List appropriate entries from Wiki, data from Wiki being stored using Forms created in Phase 2
Interaction: Choose the most appropriate entry
Screen5
Content: Enter the variables values (vol. of room, how many degrees you want to decrees, time: 1week, 1year)
Interaction: Calculate Equivalent CO2 (CO2e)
Repeat for all activities going back to Screen3
Screen6
Content: a Dashboard using screen objects in the style of those shown in Section 2.7, generating the values for CO2 e for all selected activities
Interaction: Can still take place

4.5 Summary of Results and Findings

This chapter presents the outcomes of the four phases of the research giving examples of all the design elements namely: Forms, Templates, Dashboard and navigation. The application is designed to be easily used by the end-user once implemented in the future using a web object type product. These results are interpreted for their contribution to theory and practice in the next chapter.

5 DISCUSSION AND THEORY BUILDING

5.1 Introduction to the Discussion

The findings presented in Chapter Four demonstrate the design of a sustainable practical system that could be implemented online to enable managers of SMEs to estimate and track the environmental footprint of their main business activities.

The crowd sourcing of data is the starting point of this design, when contributing end-users can add entries to the Carbon Wiki based on their estimate of emissions from their business activities. These end-users are able to use Forms to contribute to the Wiki where these Forms were created from design Templates based on a study of typical activities which could contribute substantially to the environmental footprint of a business.

The content in the Wiki provides the data for its ultimate purpose which is the Dashboard. This data is based on estimates from real practice in a wide variety of circumstances. The Dashboard is designed to be a user-friendly online application to be customised by managers and personnel for their particular SME. The future implementation of the Dashboard design will offer a sustainable practical system where contributing end-users continue to provide data which businesses use to estimate, track and reduce their environmental footprint.

From both practical and theoretical perspectives, a problem was encountered late in the process of designing the Dashboard regarding the structure of the data in the Wiki in order to design the Dashboard interface. The Forms for crowd sourcing the Wiki content did not allow for attributes of the estimates of the Footprint of different business activities that could be used by the objects in the Dashboard. By rethinking and re-designing the data and Forms to collect it, contributions were made to IS theory and practice.

Gregor and Hevner (2013) propose three levels of theoretical contributions from Design Science research: Level 1. Situated implementation of artefact; Level 2. Nascent design theory though knowledge as operational principles/architecture and Level 3. Well-developed design theory about embedded phenomena. My research is at level 2 and illustrates "how interim attempts at theorizing can be valuable in a process of theorizing (Gregor & Hevner 2013 p339)

5.2 Towards a Contribution to Theory

As previously stated, the initial theoretical emphasis in this project was the use of Activity Theory to justify and explain the need to base estimates of the environmental footprint of an SME on its business activities. Because SMEs do not have the resources of a large business, SMEs tend to use freely available carbon calculators to do such estimates but these are usually focused on *things* (particular equipment, vehicles etc) and not on *activities*. Assuming that a crowd sourced Carbon Wiki would be created and populated by others therefore two phases of research were planned: one to identify and create Templates of typical business activities with high environmental footprints, and a second to design a Dashboard interface for SME managers to access and customise data in the Wiki to the needs of their business.

Because of the various changes which emerged during the 4-year conduct of the research, the phases became different to those originally planned. Because of this, the project became a more significant design issue than had initially been anticipated. As a result of the convoluted research pathway, it was necessary to rethink the degree of the structure imposed on the Wiki, with more detailed Forms needed, to input data discovered in the recreated activity Templates.

In particular there was a need to pay attention to the structure of the data that would be collected stored and used by the Dashboard if it were to be easy to use. Following the understanding that, Activity Theory was still used as an instrumental theory to explain the unit of analysis (activity) and the approach taken for the research based on activities. However it also establishes and verifies the adoption of Design Science as a focal theory, which underpins the intellectual basis of the analysis and a re-examination of the traditional linear steps in design theory (Davidson et al., 2012). In that sense there is an element of theory building in this research.

When the design of the Dashboard application first started the design aspect of the research was guided by the traditional six steps of design theory. As mentioned previously two obstacles to the research were encountered due to external factor and imposed changes were be made.

The first obstacle was the identification of the activities where I initially had access to people from environmentally responsible small businesses through the government sponsored BLT organisation. As BTL folded before the research began, instead of interviewing people from

organisations I had to search the web and get a list of activities from the websites of different industries. This solution was adequate.

The second obstacle, which arose later in the research process, became obvious when the existing Forms for entering estimates of footprints into the Wiki meant that the collected data lacked structure. This meant that the Dashboard could not be designed to pull up elements into suitable web objects for the end-user to meaningfully manipulate without re-entering numeric data located within text fields with no guarantee of comparable values from different data entries. Additional phases were added to the design process where the activity Templates had to be modified and all the Forms used in data collection rebuilt retrospectively. This process was not clearly reflected in the traditional steps of design theory.

The solutions chosen to overcome the obstacles faced during the execution of the project were document in a paper and presented at an IS conference. Knowledge participants at the conference agreed that the solution to the problem with the Forms was a significant design challenge and one that required some new design theory building. This meant that the end product of this project was not about implementing a carefully designed Dashboard application, but the outcome of the rethinking and redesigning all the consisting components.

Thus my study reached the point of a conceptual design of the Wiki and the Dashboard where the latter could be relatively easily implemented using the type of application mentioned in Section 2.7 which contains a more detailed explanation of the Dashboard implementation and usability. Microsoft has an easy Dashboard technology which could be used for implementation however the complicated part is the study and design of Wiki with its Forms data collection and Dashboard interface based on activities.

The next section of this chapter describes the intended application of traditional design theory to this project as originally planned. The Theory Building that emerged from the actual phases of the research is explained in Section 5.4 based on the encountered complications of design although not the implementation of the Dashboard.

5.3 Application of Design Science

The six steps presented by Peffers, et.al (2008) are described in Chapter 2 as follows:

1. Identify the problem
2. Define the obstacles in reaching a solution
3. Design and Development

4. Demonstration of the solution
5. Evolution of theory and reflection
6. Communication of the findings (done in this thesis)

As described here, I originally intended to follow these in designing the Dashboard to sit on the Crowd Source Carbon Wiki.

5.3.1 Identify problem

SMEs constrained by different parameters which are specific to a small and medium sized business.

SMEs in particular cannot always afford the extra cost involved in changing to more environmentally sustainable ways of operating even if they know how best to do this. They often do not have the resources to investigate ways to assess and track their Environmental Footprint in order to find ways to reduce it. Yet they often want to do this for several reasons including the prospect of changes in legislation that could require this, well-known benefits to the image of the business of having a "green' image", and the personal desires of managers to do the right things with respect to the environment.

5.3.2 Define obstacles of solution

As mentioned above, the two obstacles to the originally planned solution were in identifying the activities and the change in construction to include the wiki Forms.

When this project was originally proposed it was designed to co-ordinate with two other projects.

One was a local government funded organisation Business Treading Lightly (BTL) which was set up to advise local SMEs on ways to reduce their carbon footprints. They had asked for a student to interview business managers of their clients to get feedback on the success of their program and accepted me to do this while collecting data for my project.

By the time I had enrolled and completed my proposal presentation the government funding for BTL had been withdrawn and the organisation had folded. As I no longer had access to their clients to interview I changed my approach to identifying business activities from physical interviewing to an online study of activities from a representative selection of company websites.

The second project with which I would co-ordinate was a group student project which would create a Carbon Wiki which would crowd source data on the carbon footprint of all manner of activities. This meant that the online application that I would produce would be a web-based Dashboard which would draw data from the Wiki. As mentioned above, a problem arose with the outcome of this project in terms of the data structures in the way data was collected and stored. This was not detected until much later in the project when the Dashboard objects were being designed. This became a more significant issue leading to a change in the design steps. It led to the need to re-examine the basic steps of Peffers, et.al (2008) and to new theory building as described in Section 5.4

5.3.3 Design and (Development)

In the design and development phase, the designing of Templates for activities which are specific for each industry is the main focus. The Templates were designed to help structure the Dashboard for each type of business and business activity. Elements would be needed to support the user experience which would follow a scenario that would allow them to select their specific business and then look for entries in the Carbon Wiki that were similar to theirs, e.g. a small restaurant in a cold/hot climate that uses electrical equipment produced from non-renewable energy supply.

The Dashboard is the artefact to be implemented and the final outcome of this project is the Templates for its design.

5.3.4 Demonstration of the solution

This step is the fourth step from the six steps presented by Peffers, et.al (2008).

In the Demonstration phase the context is usually an artefact, an IS tool used to solve the identified problem based on the context. The intended artefact in this case is an online Dashboard, sitting on a crowd-sourced Wiki that would be used to enhance the SME’s experience and help solve their problems or potential problems.

The client/context in this case is the SMEs which are willing to decrease the Environmental Footprint of their activities and create sustainable business practices. In the future, SMEs may even be required to follow the regulation imposed by different authorities to ensure that their business takes into consideration the protection of the environment - a vital action for human wellbeing.

While this Dashboard artefact was not implemented in the project, a design was produced that could easily be implemented in a product such as Microsoft Dashboard. The concept and design of the activities-based wiki and Dashboard was presented at an IS conference and well received. This constitutes the demonstration of the solution in this project.

5.3.5 Evolution- theory reflection

The evolution phase's main aim is to incrementally improve the futures of the artefact or artefacts.

In this research the theoretical aspect has a turning point, a rethinking moment due to the change in the data context where the initial set of data offered by the Wiki crowd sourcing did not provide suitable access from the object in the Dashboard.

The needs of the end-users from SMEs were collected into Templates for designing the Dashboard which constituted a major element of this study. However the more difficult part was to go back and re-designing the Wiki Forms for suitable data collection which is addressed in the next section..

5.4 New Theoretical Aspects of Design Science

When I presented the project as a design study to an IS conference (Ionescu & Hasan , 2014) I received feedback from IS experts regarding the contribution that the findings of this study bring to the Design Science. These are now presented.

The Design Science steps of Peffers, et.al (2008) appear relatively easy to follow. This approach is recommended by leaders in the field of Design Science such as Gregor and Hevner (2013) and nothing is mentioned about the possibility that such a linear approach is often not followed in practice. Real design problems are complex (Benbya, & McKelvey 2006; Kautz 2012) .and often convoluted and rarely follow a simple linear path as this study demonstrates. The design and implementation of the Dashboard was initially considered to be relatively straightforward once the Templates for the main business activities that contributed to an environmental footprint were established. Further the design of the objects in the Dashboard whereby users could draw on estimates of the CO2e of others engaged in similar business activities was not an easy process if the parameters for these estimates were not clearly available in the Wiki.

5.4.1 The redesign Challenge

As described previously, when it came to the phase of establishing requirements for the Dashboard, it was clear that there was a data structure problem. The Forms created in the Wiki for collecting input did not use standardised variables that could be used by the Dashboard to allow the end-user to make meaningful comparisons between different Wiki entries. For example, if the activity was heating a room and an entry in the Wiki from someone, say, in Iceland, giving an average Carbon Footprint of CO2, needed to provide details of how many degrees temperature rise this represented for what sized room over what length of time. The units for these details were also needed. In the original Wiki structure all these details were only discernible, if at all, by reading a textual description.

As a consequence the Dashboard design phase was delayed and the project expanded to include a complete re-design of the input Forms to the Wiki repository in order to require contributing users to enter data that included enough explicit information so users of the Dashboard could easily compare estimates of CO2e from different entries, choose one that was similar to their circumstances and enable a calculation of the CO2e for their own business activities.

A challenge came when I had to re-design the input Forms and I needed expertise from a colleague to learn to program that part of the application which dealt with the Forms. The Forms are crucial to collecting and storing usable data in the Wiki.

5.4.2 Data, process and user interface

In the early days of IS, practitioners and researchers developed the concept of structured systems analysis and design which looked at the data structures, process flows and user interface through the whole lifecycle of systems. The Dashboard was planned to be designed as a web-based user interface based on the activity Templates and implemented using a modern end-user tool such as Microsoft Dashboard. This would allow easy interaction with the Wiki.

However, in my research, the data which should have been collected with the use of crowd sourcing for the Wiki, was not structured appropriately and a series of changes and adjustments occurred. Before the Dashboard interface could be designed additional time was needed to research the data aspects of business activities and how the data could be collected in a more structured way to suit the objects in the Dashboard.

5.4.3 Towards a new theory

At the beginning of the research project, the process of designing the Dashboard interface appeared to be a straight forward process from a design theory perspective. From a study of the constraints that SMEs encounter when identifying and determining their environmental footprint, the business activities were researched and based on them the Templates were created. The need to reconsider how data was recorded and structured meant an unanticipated detour to focus on data structures and the re-designing of the Wiki input Forms. It was clear that those designing the original Forms had not sufficiently considered how data would be used in the Dashboard.

Figure 5.1 is a diagrammatic representation of the six steps that are presented by Peffers, et.al (2008), used in Design Science. This figure is illustrated here with the purpose of comparing with Figure 5.2, which is the redefined version of the traditional design science theory, based on found solutions to the obstacles that occurred during the Dashboard design process.

Traditional Design Science Theory

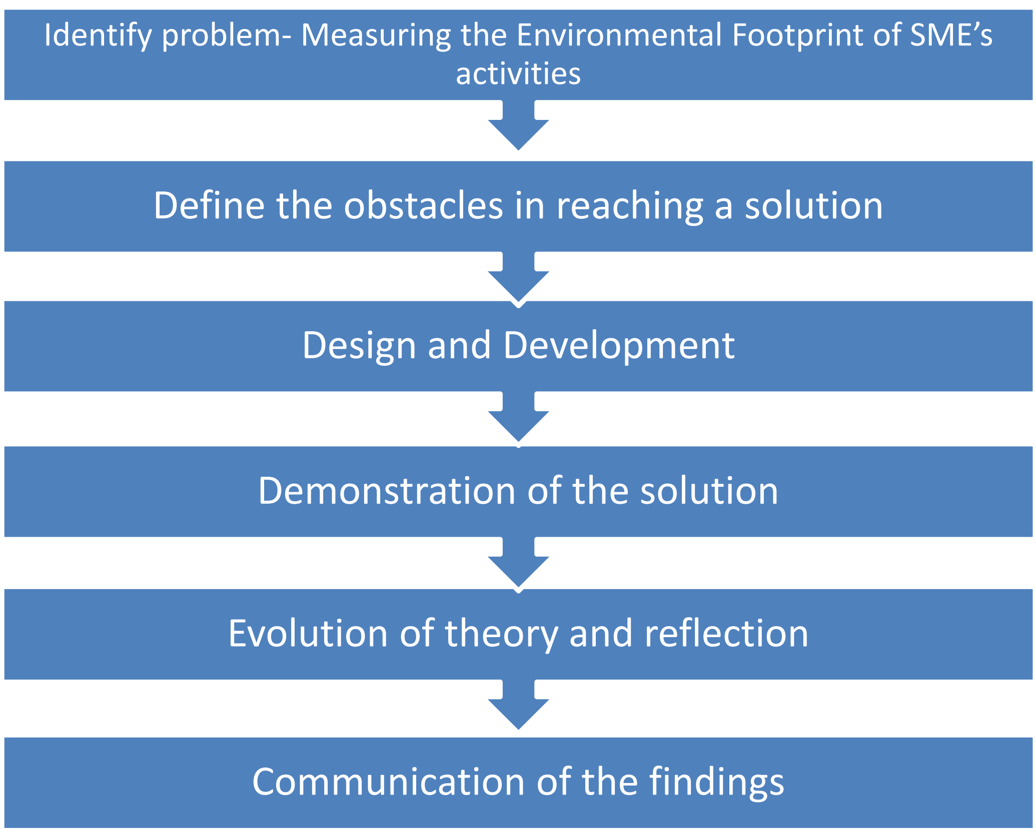


Figure 5.1 Traditional diagrammatic representation of the Design Science Theory

Figure 5.2 is a diagrammatic representation of the solution to the major obstacles that occurred during Data Structure and Design phases. It is presented as a deviation from the steps of Traditional Design Science Theory shown in Figure 5.1.

Traditional Design Science Theory New Design Theory

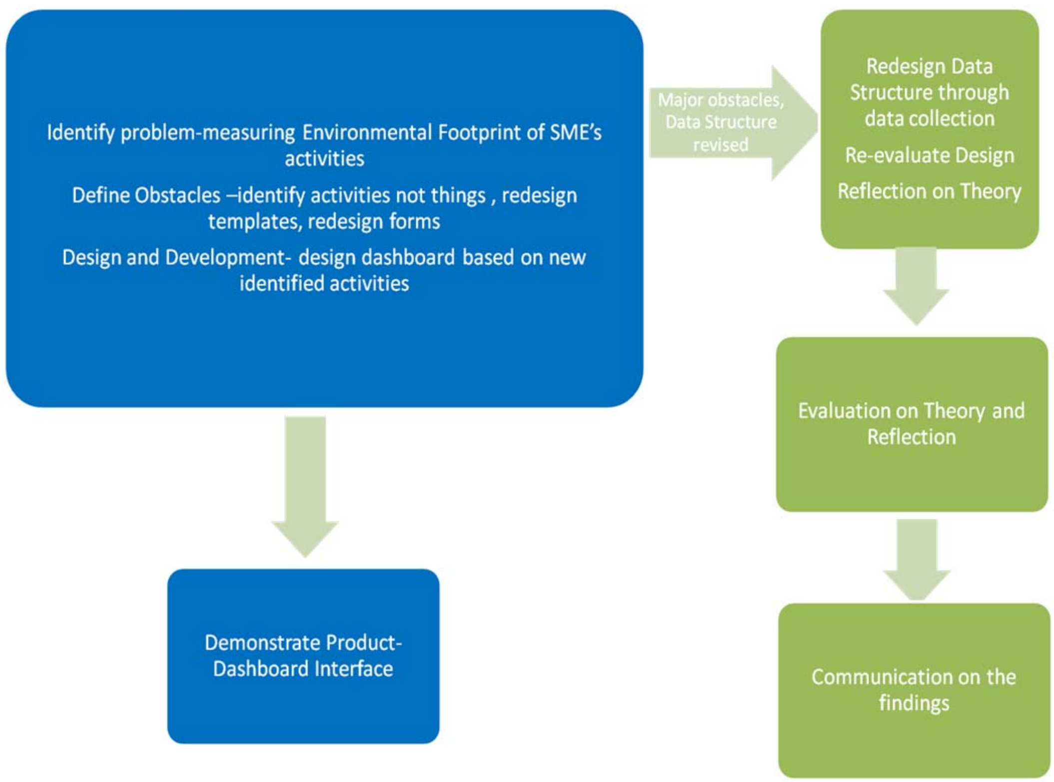


Figure 5.2 A diagrammatic representation of the addition to theory, a derived version from the traditional theory.

5.5 Applying Activity Theory to Design Science Theory

The level of complexity that this extension to Design Science implies is understandable from an Activity Theory perspective showing contradictions between the activities of the Wiki developers and my activity in designing the Dashboard.

The original start of the project had created a small repository of activities in a crowd sourced Wiki. Continuing the work on the project, having as an ultimate outcome the design of the Dashboard, I found myself in the position of being required to search for more activities and add to the original repository. In addition, my search focused on business activities that have a considerable environmental footprint to be measured. Therefore, the redesign of Templates and Forms was also necessary. Based on these changes the design of the final Dashboard emerged.

The appearance of these changes facilitated the use of the contradictions concept introduced by Activity Theory and applied to the Design Science Theory. Hence, the Design Science Theory is expanded with the occurrence of a deviation and is illustrated graphically through a comparison between two diagrams/figures 5.1 and 5.2.

6. CONCLUSION

My research is based on a gap found in the literature on the ways SMEs can determine and track their environmental footprint. It is also a response to the lack of public awareness about the currently debated pivotal matter of climate change and its effects on the future of a sustainable society. Therefore, two research questions were raised:

RQ1. What are the business activities of SMEs in different industries that are likely to have a significant Environmental Footprint?

RQ2. How can an online application be designed for the managers of SMEs to use for identifying and tracking the Environmental Footprint of their business's activities?

In order to justify and answer to the questions, an extensive review of the literature was conducted and reported in Chapter 2. This covered the topics of climate change in general and Green IS with a particular section on ways IS can help to determine and track the Environmental Footprint of a business. Having established that it is more meaningful for SMEs to focus on whole business activities rather than the equipment used, Activity Theory was introduced as an instrumental theory for this study. As design became a critical issue in the study, literature on Design Science was discussed as well as the design and usability of the Dashboard interface as appropriate for the solution to the particular design problem in this study.

This chapter summarises how these questions are answered and the contributions made to theory and practice are described in detail below.

6.1 Answering the Research Questions

The research questions were answered in the following way:

RQ1. Phase 1 and 2 of the research describes the process of answering to the first question. Briefly the two phases are summarised at this point as well.

In phase one several websites from different industries were scanned in order to identify their generic activities. The criteria of selecting the activities is based not only on common

activities of the specific businesses, but on activities which also have an environmental footprint classified according to the three Scopes defined as follow: Scope 1- emitters of different pollutants fuel, chemicals, waste management, etc.); Scope 2 - indirect emissions from use of electricity and related emissions; Scope 3 - indirect emissions from third parties such as customers and suppliers.

The generic activities are presented in Table 4.1 and a summary of activities and its scopes of different business are presented in several Tables from 4.2 to 4.6.

The answer to the first question continues with Phase 2, the phase that produces the Templates based on identified activities as intermediaries between the Forms, through which data is collected and the interfaces of the designed Dashboard.

RQ2, Phase 3 and 4 of the research, together with the Theory Building section, contain the answer to the second research question.

The third Phase is represented by the design of the Forms that are created based on previous Phase outcomes - the Templates. In the following Phase, Phase 4, the interfaces of the Dashboard are designed with the incorporation of all design components that were finalised in the previous phases.

In the process of the design of the Dashboard several obstacles appeared and several modifications were required accordingly. As a consequence, new theoretical aspects were amended to the Design Science Theory in conjunction with the application of contradictions, a concept from Activity Theory.

6.2 Contribution to Practice

A practical solution in the Form of an online Dashboard application was designed so that when built that can be categorized as a contribution to practice. This would be made available as a freely accessible online application at no cost to SME users, with the data being crowd sourced. The benefit of this application is its self-sustained capability and relevance to all businesses, considering that the foundation of the application is based on business activities in a variety of industries.

6.3 Contribution to Theory

Design Science has grown in popularity as the basis of a theory that is at the core of what the discipline of IS has always been about, namely what is learnt from the design and building of IS artefacts. The foundation of any information system or application, offline or online, is its data and the structure and organisation of that data. It has been well accepted for many decades that the design of data-structures, processes and the user interface are crucial, but historically there was debate as to which should take place first in the development of an information system. The findings and experience of this study revive the message that it is crucial to carefully choose and apply a sound design of the data, in order to avoid future complications during the design and build process of an information system.

This research contributes to the field of Green IS by presenting the successes and challenges of this project. It demonstrates the viability of a freely-available easy-to-use online system for SMEs and others can estimate and track the Environmental Footprint of their business activities. It is envisaged that this will further enable SMEs to redesign the way they do business to be more environmentally responsible.

The developed system is novel as its intended end-users of this system are owners and managers of SMEs who intend to be environmentally responsible but do not have the resources that a large organisation would have to do this. The project used publicly available applications and student resources. It is unique in focussing on activities rather than things such as appliances and relies on the holistic notion of *activity* from Activity Theory to support this approach.

The phases of the project conducted by IS scholars adopted a DSR approach which creates new knowledge through the design of IT artefacts. The limitations of a linear DSR process were discovered late in the project when requirements for the end-user dashboard were drawn up. This revealed contradictions between these requirements and the early technical focus of Computer Science students in implementing the Carbon wiki. We suggest that these types of contradictions would often occur in such resource poor, collaborative projects undertaken by environmental advocates. The case presented here suggests that more complex DSR frameworks may be needed for similar community Green IS projects.

An important breakthrough which took place in the history of Information Systems came with the advent of the concepts of Structured Systems Analysis and Design and the System

Development Life Cycle. Before this, the systems analysts were not equipped with rigorous methodologies when designing and building information systems. The breakthrough initiated the debate about the starting point in systems development regarding the use of Entity Relationship Diagrams (ERD) which deal with data or Data Flow Diagrams (DFD) which focus on processes.

This dilemma was later resolved by the Object Oriented (OO) approach to design which brought the two together. This led to the evolution of libraries of visual objects so that application design could begin with the user interface.

My initial project had the design of the end-user interface, the Dashboard, as its starting point, whereas the whole application included the crowd sourced Carbon Wiki which would enable the collection and storage of the data required by the interface. It was only during my project that it was realised how carefully the data structures should be designed in order to build the final product, including the Dashboard.

The theoretical contribution of this research is that it provides the opportunity to revisit the evolution of the analysis and design of business data and processes that are the fundamentals of Information Systems applications. The use of Activity Theory brought in the contradictions concept that I could apply it to the traditional Design Science Theory.

In the early days of data analysis and modelling the file-based type of data organisation was the norm. In the mid-sixties came the need to design more comprehensive data models due to the advancement in science, technology and business. As any IS textbook reminds us, the first data structures were on a Hierarchical model. At the beginning of the seventies the Network model started to be used and in the later seventies came the Relational model with Entity Relationship Diagrams. At the same time Data Flow Diagrams (DFD) were adopted to clearly represent the “logic of data flows between processes” (Curtis & Cobham, 2005).

Structured Query Languages (SQL) followed ERD at the beginning of the eighties, together with the Data Warehouses. In the nineties Object Oriented (OO) models joined the previous models contributing to the development of currently used Database Management Systems (DBMS) (Sumathi & Esakkirajan, 2007).

Concomitant with the advent of OO models were introduced the web enabled screen objects due to the exponential development and use of the Internet. Therefore, the existing number of end-users and applications increased the demand for “an explosive growth in the generation and collection of data” (Usama et.al, 1996).

Also the development and advance of the technology facilitates the end-user design of data, a popular example being the Microsoft Database Application, Access, which has Wizards, user-friendly features with easy end-user tools for designing stored data.

Wizards and Web enabled screen objects brought a new approach to IS data structures making them invisible to the end-user developer. Applications such as the Wiki and Dashboard reinforce the changes in the way modern technology is developed and used in today's information systems. However, the findings of this study show that while these end-user tools are great for straight forward problems, it requires the fundamental knowledge of IS professionals when it comes to the data and processes of more complicated applications.

6.4 Limitations

While the critical design work for the Wiki and Dashboard was done, the full design of the Dashboard interface to the Carbon Wiki was not finalised and the implementation was not accomplished. Due to time constraints with the extra work involved in developing the Forms to input data into the Wiki it became beyond the scope of this project.

The design presented here was by far the largest and most critical part of the project and its future implementation should be a relatively easy component of the project.

6.5 Future work

Immediate future work on this project will be both practical and theoretical. The practical work will involve the implementation of the Dashboard product, which has been noted should be relatively straightforward with a suitable application. The theoretical work could be extended using a business processing model approach.

References

Avital, M., Lyytinen, K., King, J. L., Gordon, M. D., Granger-Happ, E., Mason, R. O., Watson, R. T., 2007. "Leveraging Information Technology to Support Agents of World Benefit." Communications of the AIS, Vol.19, pp. 567-588

Baskerville, R. and Myers, M.D., 2004. Special issue on action research in information systems: Making IS research relevant to practice: Foreword. *MIS Quarterly*, pp.329-335.

Benbya, H. and McKelvey, B. 2006. "Toward a complexity theory of information systems development". *Information Technology & People* (19:1), 12-34.

Berger, P. and Luckman, T., 1967, "The Social Construction of Reality: A Treatise on Sociology of Knowledge", Doubleday, New York

Bos-Brouwers, H. E. J., 2010," Corporate Sustainability and Innovation in SMEs: Evidence of Themes and Activities in Practice", *Business Strategy and the Environment*, *Vol.* 19, Iss.7, pp.417–435, viewed 23/03/2015 http://onlinelibrary.wiley.com/doi/10.1002/bse.v19:7/issuetoc

Burstein, F. and Gregor, S., 1999, December. The systems development or engineering approach to research in information systems: An action research perspective. In *Proceedings of the 10th Australasian Conference on Information Systems* (pp. 122-134). Victoria University of Wellington, New Zealand.

Brundtland, 1987. "Report of the Brundtland Commission of the United Nations: Our Common Future". UK, Oxford University Press.

Bunge, M., 1967, "Scientific Research. The Search for Truth", Springer-Verlag, New York

CFO , 2009. "The Next Wave of Green IT: IT's role in the future of enterprise sustainability", viewed on 29 January 2009 , from www.CFO.com.

Chen, A.J.W, Boudreau, M., and Watson, R.T., 2008, "Information Systems and Ecological Sustainability", Journal of Systems and Information Technology, Sustainability and Information Systems, Vol.10, No.3, pp. 186-201.

Chen, R., Sharman, R., Rao, R.,H., Upadhyaya, J., S., 2013," Data Model Development For Fire Related Extreme Events: An Activity Theory Approach", MIS Quarterly, Vol. 37, No. 1, pp. 125-14

Cupchik, G., 2001, "Constructivist Realism: An Ontology That Encompasses Positivist and Constructivist Approaches to the Social Sciences", Forum: Qualitative Social Research, Vol.2, No.1,Art.7,viewed on October 2014,from http://nbn-resolving.de/urn:nbn:de:0114-fqs010177

Curtis, G., Cobham, D., 2005, "Business Information Systems analysis, design and practice", Person education limited, Edinburgh Gate: Harlow

Davidson, R., Martinsons, M., Ou, C., 2012, “The Roles of Theory in Canonical Action Research”, MIS Quarterly, Vol., 36, No.3, pp. 763-786.

Dix, A., Finlay, J., Abowd ,G.D. Beale, R. ,2004,” Human-Computer Interaction”, Vol. 3. , pp.834.

Elliot, S. 2011 “Transdisciplinary Perspectives on Environmental Sustainability: A Resource Base and Framework for IT-Enabled Business Transformation,” *MIS Quarterly* (35:1), pp. 197-236.

Elliot, S. and Binney, D. 2008. “Environmentally Sustainable ICT: Developing Corporate Capabilities and an Industry Relevant IS Research Agenda”, Proceedings of PACIS , 4-7 July Suzhou, China.

Engestrom, Y., 1987, “Learning by Expanding”, Helsinki: Orienta Konsultit

Engestrom, Y., 2000,” Activity Theory as a framework for analysing and redesigning work Ergonomics, Vol.43, No. 7, pp. 960-974

Filonik, D., Medland, R.,C., Foth, M.,, and Rittenbruch, M., 2013,” A customisable dashboard display for environmental performance visualisations. In Berkovsky, Shlomo & Freyne, Jill (Eds.) Proceedings of the 8th International Conference on Persuasive Technology, Springer-Verlag Berlin Heidelberg, Sydney, pp. 51-62, viewed from http://eprints.qut.edu.au/56544/

Foran, B. lenzen M. Dey C. 2005, “Balancing Act, A Triple Bottom Line Analysis of 135 Sectors of Australian Economy”, CSIRO, University of Sydney

Gartner, 2008, “Going Green: The CIO’s Role in Enterprise wide Environmental Sustainability”, Gartner EXP premier, May.

Glesne, C., 2011,” Becoming qualitative researchers: An introduction”, Pearson, Boston

Ghose, A., Hoesch-Klohe, K., Hinsche, L., & Le, L. S. (2010). Green business process management: A research agenda. Australian Journal of Information Systems, 16(2).

Gregor, S. , 2002 ,“A Theory of Theories in Information Systems,” in *Information Systems Foundations: Building the Theoretical Base*, S. Gregor and D. Hart (eds.), Australian National University, Canberra , pp. 1-20.

Gregor, S., 2006, “The nature of theory in information systems”. MIS Quarterly, Vol.30, No.3, pp. 611–642.

Gregor, S., Hevner, R., A., 2013, “Positioning and Presenting Design Science Research for Maximum Impact”, MIS Quarterly Vol. 37 No. 2, pp. 337-355

Guba, E.G. and Lincoln, Y.S., 1994. Competing paradigms in qualitative research. *Handbook of qualitative research*, *2*(163-194), p.105.

Hasan, H. Banna S. 2010, “ The Unit of Analysis in IS Theory: The Case for Activity”, *Information systems Foundations Conference*, Canberra

Hasan, H., Gould, E., Hyland, P., 1998, “Information Systems and Activity Theory: Tools in Context”, University of Wollongong Press, Wollongong

Hasan, H., Gould, E., Larkin, P. and Vrazalic, L., 2001, "Information Systems and Activity Theory: Volume 2 Theory and Practice", University of Wollongong Press, Wollongong

Heikkinen K. , 2012," Design specification of a dashboard interface for the management of steel service centres". University of Oulu, Oulu, Finland. Master's thesis, pp. 103

Hevner A.R., Chatterjee S.,(2010) "Design Research in Information Systems, Theory and Practice", Springer New York Dordrecht Heidelberg, London

Hillary, R., 2000," Small and Medium-sized Enterprises and the Environment" Greenleaf Publishing, Sheffield, UK

Hitchens, D., Thankappan, S., Trainor, M., Clausen, J., & De Marchi, B. 2005. Environmental performance, competitiveness and management of small businesses in Europe. *Tijdschrift voor economische en sociale geografie*, *96*(5), 541-557.

Hevner, A.R., March, S.,T., Park, J., RamSource, S., 2004, Design Science in Information Systems Research", MIS Quarterly, Vol. 28, No. 1, pp. 75-105 viewed on 9March 2014 from http://www.jstor.org/stable/25148625

Ionescu, C., Hasan, H., 2014, "Tracking the Environmental Footprint of Business Activities", University of Wollongong, Wollongong, NSW, Australia

ISO, 2000," Ergonomic requirements for office work with visual display terminals "

Ionescu, C., Hasan, H., 2014, "Tracking the Environmental Footprint of Business Activities", University of Wollongong, Wollongong, NSW, Australia

ISO, 2000," Ergonomic requirements for office work with visual display terminals "

Järvinen, P., 2007. Action research is similar to design science. *Quality & Quantity*, *41*(1), pp.37-54.

Kaptelinin, V.,1996, "Activity Theory: Implications for Human-Computer Interaction", in B. Nardi (Ed.), Context and Consciousness*:* MIT Press, pp. 103-116.

Kaplan B.,Truex, D., Wastell, P.,Wood-Harper, D., Trevor,A., DeGross, J.I.,2004,"Information systems research ,Relevant Theory and Informed Practice" , Academic Publishers- Kluwer, US

Kautz, K. 2012. "Information Systems Development Projects as Complex Adaptive Systems", *Proceedings of the Australasian Conference on Information Systems,* Geelong.

Klein, H., and Myers, M., 1999, "A Set of Principles for Conducting and Evaluating Interpretive Field Studies," MIS Quarterly, *Vol.*23, No.1, pp. 67-93

Kleindorfer, P. R., Singhal, K., & Wassenhove, L. N. 2005. Sustainable operations management. *Production and operations management*, *14*(4), 482-492.

Kuechler, B. and Vaishnavi, V., 2008. On theory development in design science research: anatomy of a research project. *European Journal of Information Systems*, *17*(5), pp.489-504.

Kuutti, K. And Molin-Juusttila, T., 1998, "Information Systems Support for 'Loose' Coordination in a Network Organisation: an Activity-Theory Perspective", Information Systems and Activity Theory: Tools in Context, Department of Business Systems University of Wollongong, University of Wollongong Press, pp.73-93

Leontiev, A.N.,1981, "Problems of the Development of Mind", Moscow

Lepoutre, J., Heene, A., 2006, "Investigating the Impact of Firm Size on Small Business Social Responsibility: A Critical Review":, Journal of Business Ethics, Vol.67, pp.257-273

Lincoln, Y. S., Guba, E., 2000," Paradigmatic controversies, contradictions, and emerging confluences". In Norman K. Denzin and Yvonna S. Lincoln (Eds.), "The handbook of qualitative research", London, pp.163-188

Loeser, F. 2013. "Green IT and Green IS: Definition of Constructs and Overview of Current Practices," in *Proceedings of the 19th Americas Conference on Information Systems*, Chicago, August 14-17

Loos, P., Nebel, W., Gómez, J.M, Hasan, H., Watson, R.T, vom Brocke J, Seidel, S., Recker, J .,2011," Green IT: a matter of business and information systems engineering? ", Business & Information Systems Engineering , Vol.3, No.4, pp.245–252

Malhotra, A., Melville, N. P., Watson, R., T., 2013, "Spurring Impactful Research on Information Systems for Environmental Sustainability", MIS Quarterly, Vol. 37, No. 4, pp. 1265-1274

March, S.,T., Smith, D.,F., 1995, "Design and Natural Science research on Information Technology", Decision Support Systems, Vol.15, pp.251-266

Majchrzak A. and Malhotra A. 2013 "Towards an information systems perspective and research agenda on crowdsourcing for innovation" *Journal of Strategic Information Systems* 22 pp 257– 268

Markus, M. L., and Silver, M. S. 2008. "A Foundation for the Study of IT Effects: A New Look at DeSanctis and Poole's Concepts of Structural Features and Spirit, " Journal of the Association for Information Systems, Vol.9, No.10, pp. 609-632.

Matthews, S., Hendrickson, C. and Weber, C., 2008. "The Importance of Carbon Footprint Estimation Boundaries", Environmental Science &Technology, Vol.42, No.16, pp.5840

McCormick, J.,1986, " The Origins of the World Conservation Strategy", Vol 10 No. 3, pp177-187

Melville, N., 2010. "Information Systems Innovation for Environmental Sustainability", *MIS Quarterly* Vol. 34, No. 1, pp. 1-15

Melville, N., Saldanha, T.,2013, "Information Systems for Managing Energy and Carbon Emission Information: Empirical Analysis of Adoption Antecedents", 46th Hawaii International Conference on System Sciences, IEEE Computer Society, pp.935-942

Nardi, B., 1996, " Context and Consciousness: Activity Theory and human-computer interaction", Cambridge, MA: MIT Press

NGERS,2013, Australia National Green House Accounts Viewed Feb102014, from 2014http://www.climatechange.gov.au/sites/climatechange/files/documents/07_2013/national-greenhouse-accounts-factors-july-2013.pdf

Niiniluoto, I., 1999, "Critical Scientific Realism", Oxford University Press, Oxford

Nunamaker Jr, J. F., Chen, M., & Purdin, T. D. 1990. Systems development in information systems research. *Journal of management information systems*, *7*(3), 89-106.

Orlikowski, W. And Iacono,C., in Vijay Vaishnavi and Bill Kuechler,2001, "Desperately Seeking the "IT" in IT Research-A Call to Theorizing the IT Artifacts", Information Systems Research, Vol.12, No.2,pp.121-134, viewed on January 2014 from http://www.desrist.org/desrist/content/design-science-research-in-information-systems.pdf

Pachauri R. Allen M. Minx J. 2014, Climate Change 2014: Synthesis Report accessed from http://www.de-ipcc.de/_media/SYR_AR5_LONGERREPORT_.pdf March 2016

Paulos, E., Kim, S., Kuznetsov, S., 2011," The rise of the expert amateur: Citizen science and microvolunteerism. From Social Buttery to Engaged Citizen: Urban Informatics,Social Media, Ubiquitous Computing, and Mobile Technology to SupportCitizen Engagement" pp. 167

Peffers, K., Tuunanen, T.,Rothenberger, M.,A.,Chatterjee, S., 2007, "A Design Science Research Methodology for Information Systems Research", Journal of Management Information Systems, Vol.24, Iss.3, pp.45-77

Petts, J., Herd, A., Gerrard, S., & Horne, C. 1999. The climate and culture of environmental compliance within SMEs. *Business strategy and the Environment*, *8*(1), 14.

Philipson, G., 2010, "Carbon and Computers in Australia. The Energy Consumption and Carbon Footprint of ICT Usage in Australia in 2010", A report for the Australian Computer Society by Connection Research ,Australian Computer Society, pp.9-12

Popper, K., 1978. Natural selection and the emergence of mind. *Dialectica*, *32*(3-4), pp.339-355.

Porter, M. E., & Kramer, M. 2011. Creating shared value: Redefining capitalism and the role of the corporation in society. *Harvard Business Review*, *Jan*.

Quinn, J. J. 1997. Personal ethics and business ethics: The ethical attitudes of owner/managers of small business. *Journal of Business Ethics*, *16*(2), 119-127.

Rees M. J. 2001 Evolving the Browser Towards a Standard User Interface Architecture,. Third Australasian User Interface Conference, Melbourne, Australian Computer Society Inc

Rose, S., 2008. 'Staying Green in a Tough Economic Climate", Harvard Business Review: viewed on 10February 2014 , from http://hbrgreen.org/2008/03/the_hard_economics_of_green.html

Seidel, S., Loos, P., Watson, R., T., 2013, "Green Information Systems for Environmental Sustainability", Business &Information Systems Engineering, No.5, pp. 295-297

Seidel, S.,Recker, J., Brocke, J.vom, 2013, "Sensemaking and Sustainable Practicing Functional Affordances of Information Systems in Green Transformations", MIS Quarterly, Vol. 37, No. 4, pp. 1275-1299

Sumathi, S., Esakkirajan , 2007,"Fundamentals of Relational Database Management Systems", Library of Congres Number:2006935984, ISSN print edition:1860-949 X, ISSN electronic edition:1860-9503, ISBN-10 3-540-48397-7 Springer Berlin Heidelberg ,New York

UNCHE, 2007, "United Nations Conference on the Human Environment (UNCHE)", Stockholm, Sweden, viewed Feb 10, 2014, from http://www.eoearth.org/view/article/156774/

Usama, M. F., Padhraic Smyth, G., Uthurusamy, R.,1996," Advances in Knowledge Discovery and Data Mining", viewed on 3 February 2015, from http://www.citeulike.org/group/2902/article/1550195

van Aken, J.E., 2004 , "Management research based on the paradigm of design sciences: The quest or field-tested and grounded technological rules", Journal of Management Studies, Vol.41, No. 2, pp. 219-246.

Vijay, V. and Kuechler, B., 2004, "Design Science Research in Information Systems", viewed 23Octomber 2013, from http:// www.desrist.org/design-research-in-information-systems/

Vygotsky, S., 1978 , "Mind and Society", Harvard University Press, Cambridge, MA.

Walls, J. G., Widmeyer, G. R., & El Sawy, O. A. 1992. Building an information system design theory for vigilant EIS. *Information systems research*, *3*(1), 36-59.

Wang, Y. and Zhang, X., 2001. A dynamic modeling approach to simulating socioeconomic effects on landscape changes. *Ecological Modelling*, *140*(1), pp.141-162. Watson, R. T., Boudreau, M.-C., and Chen, A. J. W. 2010, "Information Systems and Environmentally Sustainable Development: Energy Informatics and New Directions for the IS Community," *MIS Quarterly* (34:1), pp. 23-38.

Weber, M., 1978, " Economy and Society", Vol.3. , University of California Press, Berkeley