Sustainable Development in Thailand Supported by Industrial Design Education

by

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Doctoral Thesis

Submitted in partial fulfilment of the requirements for the award of

Doctor of Philosophy of Loughborough University

December 2016

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Abstract

The awareness of sustainable development has been increasing significantly in the Thai manufacturing industry since the financial crisis in 1997. The government has launched several initiatives to promote the development of sustainable products as the concept has a potential to stimulate the national economy and address the sustainability issues. Although the progress has been reflected through the launch of numerous products in the market, most of the products available were only claimed to be sustainable or environmentally friendly. Education is a prerequisite to achieve the integration of sustainable design as it equips stakeholders with knowledge and skills required to be the future decision makers. In other words, it enables designers to create products that contribute to sustainable development. However, the researcher found a lack of sustainable design learning in Thai industrial/product design courses.

This situation has motivated the researcher to carry out this PhD research with an aim to support the implementation of education for sustainable development (ESD) into Thai higher education institutions (HEIs). The literature review emphasised the need to tailor the theoretical framework for Thai lecturers due to the lack of ESD training and appropriate materials. It also indicated the lack of publications related to the Thai context and the requirements to identify barriers and needs of the target users.

The shortfall was addressed through a series of interviews; experts from three different disciplines (government, business and education sectors) were invited to participate in the interview sessions and reveal the status of sustainable design and ESD in Thailand. The findings were then used to construct the ESD framework that is specific to Thai industrial/product design courses. The *SustainAble* web-tool was developed to make it more effective in enabling the framework to comply with the needs of Thai design lecturers.

Usability testing was employed to test the framework that was presented through the web-tool. The framework evaluation demonstrated the success of the framework development and underlined the need for the web-tool. The tool can fulfil the framework and allow it to be practically applied in the context of Thai design education.

Acknowledgements

First and foremost, I would like to thank my supervisors, Dr. Mark Evans and Dr. Debra Lilley, for their patience, expertise, invaluable academic and personal support during my PhD study. I would also like to thank my independent assessor, Prof. Tracy Bhamra for her useful comments.

I would like to thank all participants involved in the empirical studies of this research project. This thesis would not have been possible without their time and information.

Lastly, I would like to say thank you to my internal examiner Dr. Rhoda Trimmingham for helping me to work through all the corrections.

List of publications

PASUPA, S., EVANS, M. and LILLEY, D., 2012. The status of sustainable design in Thailand. In: ISRASENA, P., TANGSANTIKUL, J. & DURLING, D. (eds.), Proceedings of the Design Research Society Conference (DRS 2012 Bangkok), Chulalongkorn University, Bangkok, Thailand, 1 - 5 July 2012, pp. 1454 - 1464.

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List of Abbreviations

AIT	Asian Institute of Technology
ASEAN	Association of Southeast Asian Nations
DIW	Department of industrial works
EE	Environmental Education
ESD	Education for Sustainable Development
FTI	The Federation of Thai Industries
HEI	Higher Education Institutions
KU	Kasetsart University
KMITL	King's Mongkut Institute of Technology Ladkeabang
LCA	Life Cycle Assessment
MTEC	National Metal and Materials Technology Center
OTOP	One Tumbon One Product
RoHS	Restriction of Hazardous Substances Directive
SEP	Sufficiency Economy Philosophy
SMCEs	Small and Micro Community Enterprise
SME	Small and Medium Enterprises
TBL	Triple Bottom Line
TCDC	Thai Creative and Design Center
TEI	Thailand Environment Institute
TGDN	Thai Green Design Network
TQF	Thai Qualifications Framework
UN	United Nation
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNEP	United Nations Environment Programme
XCEP	eXcellent Center for Eco Products

Chapter 1: Introduction

1.1 Background to the research

This research started from an ambition to contribute to the integration of sustainable design in the Thai manufacturing industry. As a Thai industrial/product designer, the researcher has seen that Thailand has great potential to develop and produce sustainable products due to the abundance of raw materials and local wisdom that can be applied to craft-based manufacturing. Moreover, the government has given more focus to the implementation of sustainable development (the root of sustainable design) due to the negative effects from industrialisation.

Between 1957 and 1992, the Thai government emphasised economic policies to stimulate the national economy (Baker, 2007). One of the solutions was to shift the country's economy from an agriculture-based to an industrial-based one. This attempt was successful and the country is now considered as one of the Newly Industrialised Countries (NICs). The gross domestic product (GDP) of the industrial sector in Thailand has been growing at a double-digit rate during the course (Panayotou et al., 1990) and accounted for more than twice that of the agricultural GDP since 1989; figures in 1989 were 15.8% and 33.8% respectively (Bank of Thailand cited in Akkaraseranee, 2004). Although the industrialisation enabled the country to gain prosperity, this development is not sustainable as it causes negative impacts on both society and environment. Along with the attempt to address domestic environmental and social problems, the United Nations (UN), at the international level, has also encouraged Thailand to start implementing sustainable development to address the problems.

The Thai government has responded to these calls by ratifying related declarations such as Agenda 21 and the Johannesburg Plan in 1992 (UNEP, 2006). The awareness of sustainable development was significantly raised and became more widespread in

the Thai manufacturing industry after the financial crisis in 1997.[1] The evidence for this can be seen through a number of initiatives launched by the Thai government after the crisis to support sustainable product development to stimulate the national economy (Mungcharoen, 2006). The literature review identified that these initiatives can be divided into two categories. Firstly, One Tambon One Product (OTOP) aims to contribute to the national economy by stimulating rural development; Each Tambon (district) has been encouraged to develop their own products (based on their local resources) and trade them to gain higher incomes (Natsuda et al, 2012). Secondly, for eco-product development: the government has provided support that enables Thai companies to comply with environmental regulations to export products. These two initiatives have increased awareness of sustainable design and influenced its integration in the Thai manufacturing industry. Significant progress in the implementation of sustainable design is demonstrated through the product design fair in Bangkok called BIG+BIH. It is one of the largest product design fairs in Thailand that is organised annually by the Thai government. The design fair considered eco-products as one out of eight product categories in 2014. Many OTOP products were also exhibited and traded in the fair (BIG+BIH, 2014).

However, many Thai products have claimed to be sustainable or environmentally friendly but they cannot comply with the criteria for sustainable product design. For example, environmental sustainability requires the consideration of the whole product life cycle, but many Thai products only focus on a few elements of the cycle. *"Many Thai designers misunderstand that eco-design is about designing products by using wasted materials. But it is only one of the processes in the whole product life cycle"* (CreativeMOVE, 2015).

Sustainable design and/or eco-design have not been successfully integrated into the Thai design industry because designers lack relevant expertise (Pasupa et la., 2012). Designers are directly related to the implementation of sustainability as they play a

[1] The collapse of the Thai currency led the country to face a crisis when the

key role in selecting materials and manufacturing processes (Mackenzie et al., 1991; Bhamra and Lofthouse, 2007). Along with the role that directly relates to the design profession, Chick and Micklethwaite (2011) present ways designers can address societal challenges and transform society to be more sustainable. Designers can influence sustainable behaviour through the new product development process (Lilley, 2009; Tang and Bhamra, 2008). The lack of capability in sustainable design has arisen because of limited opportunities for study, with HEIs being acknowledged as the environments in which to equip future decision makers/designers with the necessary knowledge and skills (Arima et al., 2006; Ramirez, 2007).

The Thai government has acknowledged the need to implement Education for Sustainable Development (ESD) owing to the calls from the UN and the Association of Southeast Asian Nations (ASEAN). However, literature shows that ESD implementation is not widespread in Thai HEIs (Klinpikul and Srichandr, 2010; Lindahl, 2008). Activities related to the implementation of ESD have tended to focus on the fields of engineering and environmental science that easily link to sustainability. Lack of lecturers with ESD qualifications is one of the common barriers to implementing ESD in HE (Symons, 2008; UNICEF, 2013). Learning resources are other alternative channels to disseminate sustainable design knowledge and enable lecturers to expand their knowledge. Previous research projects have developed resources to stimulate the implementation of ESD in HEIs (e.g. Diselmex (Victoria-Uribe, 2008); Information/Inspiration (Lofthouse, 2006); Design for Sustainability (D4S) (Crul and Diehl, 2006)). Although some resources have been developed to facilitate the learning and teaching of sustainable design, they are not appropriate for Thai industrial/product design lecturers due to the difference in context. UNESCO (2012) highlights that local relevance is the key to achieve ESD as each country has a different ESD challenge and learning culture. The PhD study then proposes to facilitate Thai design lecturers to acquire the ESD qualifications by developing new material.

1.2 Research aim and objectives

The overall aim of the research is to propose a methodological framework to contribute to the learning and teaching of sustainable design in undergraduate industrial/product design courses in Thailand.

The objectives are to:

1. To critically review the literature and grey literature relating to:
    - The relationship of sustainable development and the design profession
    - ESD
    - ESD learning materials or mechanisms that are or can be related to industrial/product design education
2. To explore and understand the Thai context including:
    - The implementation of sustainable development in Thailand
    - The existing sustainable development activities
    - The implementation of ESD in Thai HEIs (especially in industrial/product design courses)
3. To investigate (explore and describe) sustainable design modules that are available in Thai HEIs by focusing on product/industrial design courses:
    - To identify obstacles that limit the knowledge extension of sustainable design
    - To evaluate teaching and learning techniques that are currently employed
4. To develop more appropriate learning materials that can effectively contribute to the implementation of ESD in Thai product design education:
    - To identify the target users
    - To identify the criteria to develop the framework
    - To identify the solution to disseminate the framework
5. To evaluate and validate the framework by collecting feedback from design lecturers.

1.3 Thesis structure

This thesis is comprised of a further 8 chapters:

Chapter 2: Literature review

This chapter explores relevant literature to satisfy the research aim which is to develop a learning framework and contribute to integrating ESD into Thai industrial/product design education. The literature review enables the research project to identify an appropriate approach for ESD teaching and learning. It also partly provides an overview of sustainable design and ESD implementation in Thailand. However, the review indicates the need to conduct an empirical study to investigate the Thai context more fully owing to the lack of related publications and secondary data.

Chapter 3: Research methodology

This chapter outlines the overarching research methodology carried out to achieve the aim and objectives described in Chapter 1. The methodology is presented through 4 research phases including: Phase 1 a review of related publications and secondary data; Phase 2 an empirical study to investigate the Thai context; Phase 3 the development of a more appropriate material (a framework) to contribute to the implementation of ESD in Thai industrial/product design education; and Phase 4 an evaluation of the new framework.

Chapter 4: The implementation of ESD in the Thai product design education

The literature review indicated a limited amount of literature exploring sustainable design in the Thai context. Thus, semi-structured interviews with industry experts, government agencies and product design lecturers were conducted to address this shortfall. This section unveils the status of ESD implementation in Thai industrial/product design education, which was required to develop a more appropriate framework.

Chapter 5: The development of the framework and web-based tool (*SustainAble*.in.th)

The composite findings of the literature review and interviews with experts from several disciplines were utilised to develop a new framework for learning and teaching sustainability in undergraduate product design courses in Thailand. This chapter introduces the framework along with two additional sets of information that were required to enable lecturers to gain an understanding of the framework and can provide feedback.

Chapter 6: Framework evaluation

Chapter 6 presents findings from the evaluation of the framework and *SustainAble* web-tool. This chapter first identifies the aim and objectives of the evaluation and then presents the method used which was usability testing. The findings are then presented in two major sections: framework evaluation results (Section 6.4) and web-tool evaluation results (Section 6.5). At the end of the chapter, all the findings from this evaluation are drawn together to measure user satisfaction and identify shortcomings in the framework and web-based dissemination tool.

Chapter 7: Discussion

This chapter draws together, discusses and compares all collective findings with other similar research projects. The new framework is compared with other ESD materials that have the potential to be used in Thai industrial/product design education. The chapter also unveils specific features of the new framework and its complementary element (information section). At the end of the chapter, the keys to success for the framework development are identified and presented.

Chapter 8: Conclusion & future work

The final chapter provides a summary of the research project and discusses key findings which emerged from the PhD. It starts by demonstrating how the research aim and objectives have been fulfilled. The chapter also reveals the limitations of the research and recommends further work that could address them.

Chapter 2: Literature review

2.1 Introduction

The research commenced with a review of relevant publications and secondary data. The findings from the literature review were used to identify gaps in knowledge and design the methodology to conduct empirical studies. This chapter draws together the literature review by dividing into seven core areas as shown in Figure 1.

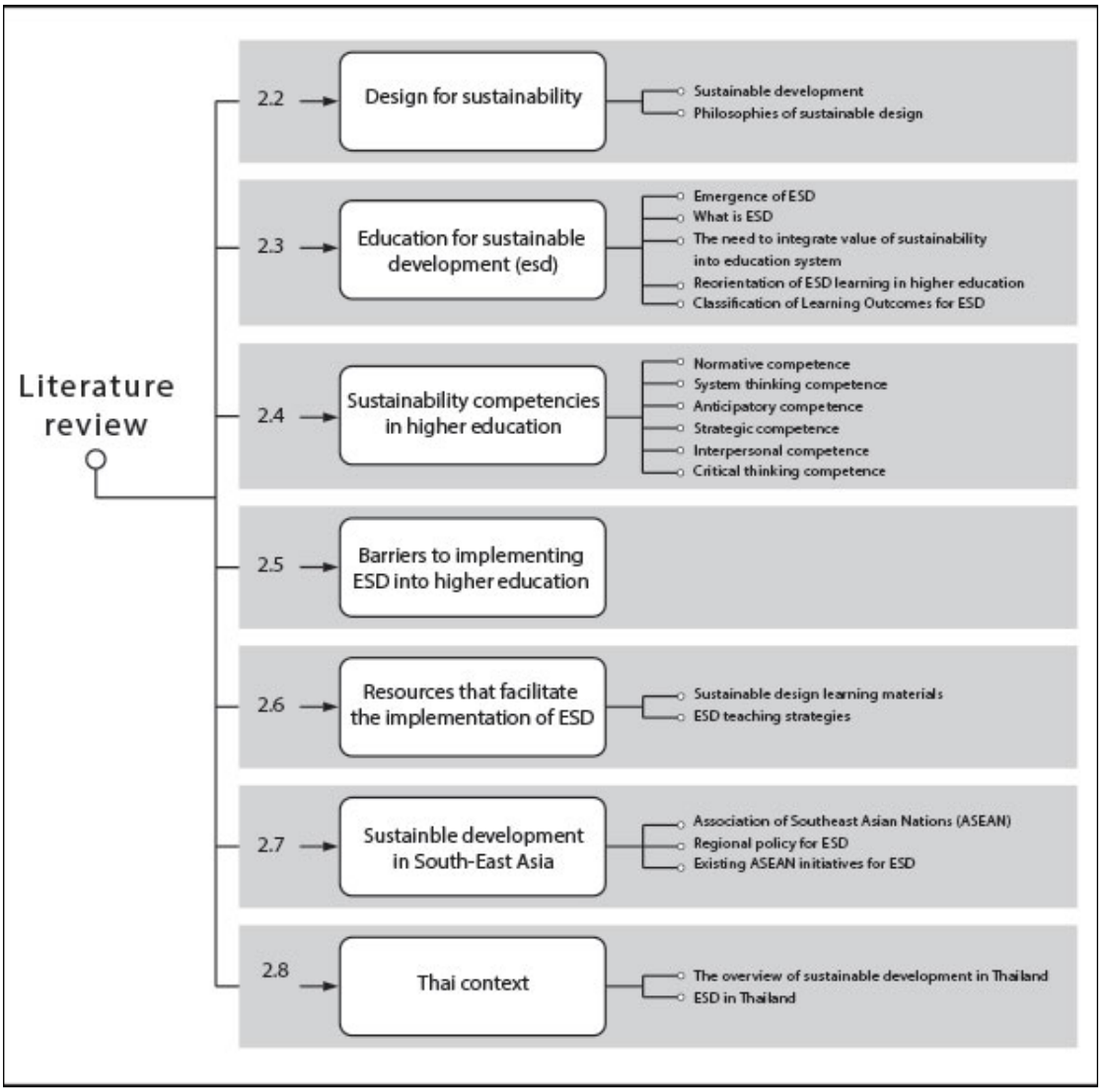


Figure 1: Literature review areas

2.2 Design for sustainability

Human activities are the main cause of social and environmental problems. For example, burning fossil fuels is one of the causes of many problems such as climate change, air pollution and acid rain (Brundtland et al., 1987). The emergence of these problems has influenced the implementation of sustainability. The design profession and academia have also responded to this call through the development of theories and methods that contribute to sustainable development. This section begins by introducing the meaning of sustainable development and describes associated design philosophies and their relationships.

2.2.1 Sustainable development

Natural resources in the biosphere are required to sustain humankind by enabling survival and the development of communities, but future generations may face a lack of these important supplies that were consumed by previous generations (Burton, 1987). After the industrial revolution, negative impacts from the overuse of natural resources started to emerge. The awareness of environmental and social concerns has become widespread and, thus, the concept of 'sustainable development' has evolved. The term was coined in 1987 in a UN report called 'Our Common Future' or the 'Brundtland Report'. "*Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (Brundtland et al., 1987; p.41).

Researchers (Elkington, 1998; Yencken and Porter, 2001) have expanded on the concept by indicating three main aspects of sustainability:

- Economic focus (material prosperity)
- Environmental focus (maintain ecological balance and avoid negative environmental impacts)
- Social focus (welfare and cohesion)

These three pillars are also known as the 'Triple bottom line' (TBL) (Elkington 1998). McDonough and Braungart (2002) state that manufacturers are expected to consider environmental and social aspects while generating economic benefit to shift industry

toward sustainability. The purpose of the TBL is to assess an organisation's impacts across the three pillars.

2.2.2 Philosophies of sustainable design

Sustainable design is a subset of sustainable development and has been implemented in organisations to provide business benefits to companies e.g. cost savings and increased marketability (Bhamra and Lofthouse, 2007). The connection between sustainable design and sustainable development is shown in Figure 2.

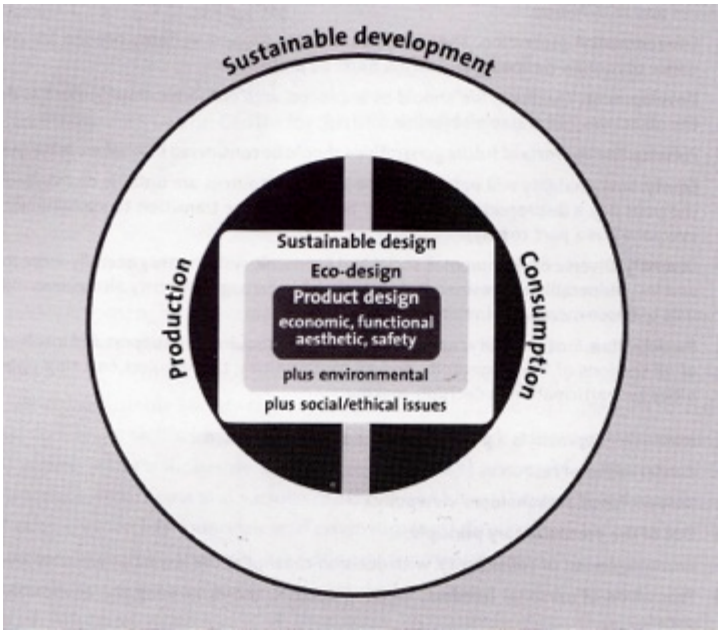


Figure 2: The eco-design, sustainable product design and sustainable development (Charter and Tischner, 2001; p.469)

Industrial/product design is a stage of the product development process that can make a key contribution to the creation of a sustainable product because it can influence the specification of production processes and materials selection (Mackenzie et al., 1991; Bhamra and Lofthouse, 2007). Consequently, philosophies of design that relate to sustainable development have been identified and interpreted in a variety of ways. This section will explain the role of designers, particularly industrial/product designers, and define philosophies of sustainable design by dividing them into three categories: green design, eco-design, and design for sustainability. Table 1 presents definitions of design philosophies for sustainable design. Bhamra and Lofthouse (2007) reveal that the evolution of sustainable design progressed from green design to eco-design through to design for sustainability.

Table 1: Description of environmental design philosophies (retrieved from Bhamra and Lofthouse, 2007)

	Name of Philosophies	Description
1	Green Design	"Green Design focus on single issues, for example the inclusion of recycled or recyclable plastic, or consideration of energy consumption"
2	Eco-design	"Environmental considerations are considered at each stage of the design process"
3	Design for Sustainability	"Design that considers the environmental (for example resource use, end of life impact) and social impact of a product (for example usability, responsible use)"

Nurse (2008) also supports this chronological order of the relevant concepts and notes that sustainable design typically focused on the environmental pillar but was later refined to link with social and economic aspects. The above three areas are expanded in the following section.

2.2.2.1 Green Design

The manufacture and use of products generate pollution that has been linked to environmental problems. Designers are therefore encouraged to reduce the environmental impact of this activity (Mackenzie et al., 1991). Awareness of green design was introduced before the European industrial revolution (Mackenzie et al., 1991). Consequently, various strategies of green design have been implemented in the product design industry, such as resourcing material locally, design for disassembly and recycling. Bhamra and Lofthouse (2007) and Chick and Micklethwaite (2011) identify green design as a design philosophy that can reduce environmental impact from the production of products by focusing on single issues such as recycling or avoiding hazardous materials.

2.2.2.2 Eco-design

Charter and Tischner (2001) define eco-design as, "*a strategy that aims to integrate environmental consideration into product design and environment*" (p121). The aim of this approach is to decrease the energy and resources of consumption and environmental impact. Bhamra and Lofthouse (2007) and Chick and Micklethwaite (2011) (Table 1) clearly indicate that frameworks of green design and eco-design are

different; green design normally focuses on a single issue while eco-design considers the entire life cycle of products. Ljungberg (2005) refers to eco-design as 'Design for the Environment' and suggests several strategies that contribute to an eco-design approach, such as choosing clean production processes, avoiding hazardous and toxic material and maximizing the efficiency of the energy used for production.

2.2.2.3 Sustainable design

In the twenty-first century, several definitions of sustainable design have been proposed. The principal concern of this philosophy is to implement sustainable design methods to make a positive contribution to the environment and society while generating economic benefit (Sherwin, 2006). Sustainable design has the capacity to reduce negative environmental and social impacts during the product life cycle (Masera, 1999). Some researchers (Charter and Tischner, 2001; Bhamra and Lofthouse, 2007) have argued that sustainable design has developed from eco-design by adding consideration of social aspects. The relationship between these two philosophies is shown in Figure 2. In addition, Charter and Tischner (2001) present typical issues that should be considered within sustainable design which have been grouped into three aspects following TBL as shown in Table 2.

Table 2: Typical sustainable product design concerns (Charter and Tischner, 2001)

Economic Issues	Environmental Issues	Social/Ethical Issues
- Technological feasibility - Financially feasibility - Short-and long-term profitable - Adequate pricing	- Waste minimization - Cleaner manufacturing - Cleaner material - Eco- efficiency - Less material - Less energy - Renewable resources - Renewable energy - Recycling	- Fair trade - Equitable policies - 'Good' employment - Condition of work - Investment in communities - Support for regional economy - Cruelty-free - Satisfaction of real needs - More customer value - Better system - Participation - Equality (gender)

2.3 Introduction to Education for Sustainable Development (ESD)

It has been widely acknowledged that education is an imperative element to achieve sustainable development. ESD has been promoted and implemented around the globe and a great number of publications have been published to contribute to its implementation. This section presents the previous work by starting with the emergence of ESD (Section 2.3.1) and clarifying its meaning (Section 2.3.2). Several researchers (e.g. Fadeeva et al, 2010; Moore, 2005; Sterling, 2001) have underlined the need for the reorientation of ESD as the traditional education system is not appropriate. One of the predominant topics is to integrate values inherent to sustainable development. This section elaborates the need to integrate sustainability values into education systems (Section 2.3.3) and reorientate education for ESD (Section 2.3.4).

2.3.1 Emergence of ESD

Education is considered as a key element for leading change towards sustainability as it can create an awareness of sustainable development and facilitates greater

understanding of sustainability issues (Buckler and Creech, 2014; Barth et al., 2007). Since the Stockholm Declaration in 1972, ESD has been widely acknowledged and is even more important. The evidence for this can be seen in the increase of publications since 1972 (Sohn, 1973), which emphasise the need to integrate ESD into all levels of education. This sub-section aims to provide a short overview of ESD and its evolution as shown through a timeline presented in Figure 3. The relationship between Environmental Education (EE) and ESD is also explored at the end of the sub-section.

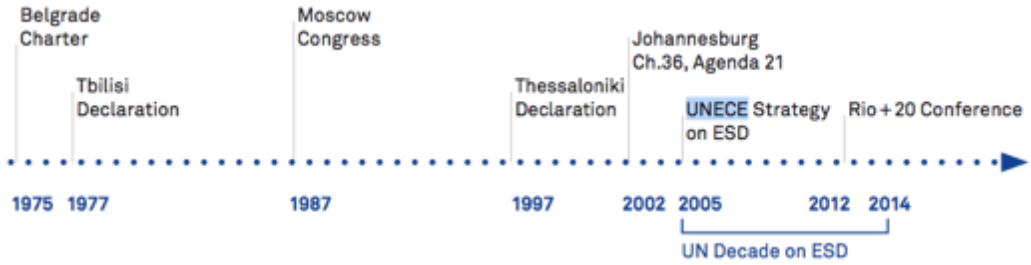


Figure 3: The time line of EE towards ESD (Alampei et al., 2013)

As shown in Figure 3, the history of ESD began with the emergence of environmental education (EE) in 1970s. The UN and its affiliations, including UNESCO, UNEP, and IEEP, can be considered as the key organisations because they have cooperated to launch many ESD initiatives. After the Stockholm Conference's identification: the importance of education, the lead organisations have continued to promote and implement EE. The first official definition of EE is provided in the Belgrade Charter that was the outcome from the UN workshop on EE (McKeown and Hopkins, 2003). 96 participants from 60 countries were invited to discuss and formulate the global framework of EE including basic principles, an aim, and objectives (Scoullos, 2010). It was then updated and recommended for adoption in 66 UN member states which signed the Tbilisi Declaration in 1997 (Alampei et al., 2013). Although EE has been integrated in many countries, ecological degradation and pollution increased. Along with these problems, people also faced other social issues including poverty and a wider gap between rich and poor (Alampei et al., 2013). Consequently, the Moscow Congress (1987) was organised to rearrange the international strategies for action in the 1990s. In the same period, the concept of sustainable development was initially

promoted and became more widespread. ESD then emerged and was utilised to promote the concept of sustainability. A new type of approach to design education has been developed from EE by embracing social issues (Sterling, 2004). Along with the Thessaloniki Declaration (Knapp, 1998) and Agenda 21 (Sitarz, 1993), the UN declared the period between 2005 and 2014 to be the Decade of Education for Sustainable Development (DESD) to emphasise the role of education in contributing to a sustainable future (Combes, 2005). UNESCO was appointed as a lead agency to accelerate the implementation of ESD and achieve its four objectives:

- Facilitating networking, linkages, exchange among stakeholders in ESD
- Increasing quality of learning and teaching for ESD
- Enabling member states to achieve Millennium Development Goals (MDGs) through ESD
- Provide member states with opportunities to incorporate ESD and reorient their education (Arima et al., 2006)

Although it is widely accepted that ESD has been evolved from EE, some authors (Kopnina, 2012; McKeown and Hopkins, 2007) have identified and offered other views of the relationship based on the broad or narrow interpretation of EE and its historical implementation in each country (Pavlova, 2011). Various models of the connection between EE and ESD have been presented (Wals, 2009; McKeown and Hopkins, 2007; Hesselink et al., 2000).

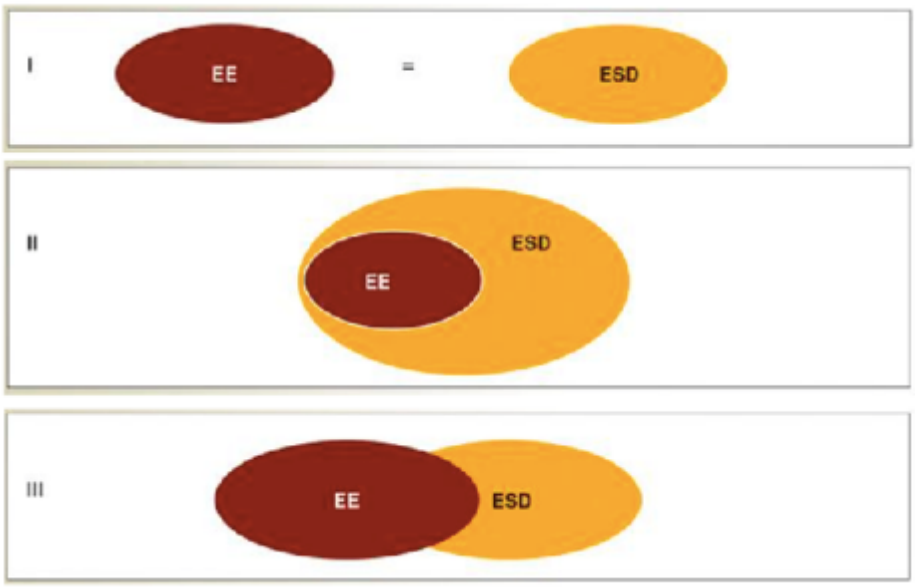


Figure 4: 3 examples of the relationship between EE and ESD from UNESCO report (Wals, 2009; p.29)

Figure 4 shows how the relationship models have been classified into three groups:

- **EE is ESD**: In some countries, EE has been broadly interpreted to embrace social issues including ethics, poverty, and inequity. These countries have successfully carried out a great number of EE initiatives and have a strong EE tradition. The rise of ESD cause distraction of existing EE activities because contributors and policy makers consider EE as an out-of-date topic and stop providing support. However, EE still remains popular and is implemented in some countries where it is possible to identify and accept the concept of EE rather than ESD.
- **EE is part of ESD:** Although the UNESCO white papers concluded that social issues such as management of natural resources and conservation of nature are part of the agenda for EE (McKeown and Hopkins, 2007), EE implementation has been given the highest priority and considered as a national agenda in many countries, though narrowly focusing on environmental issues as a way of reducing and preventing environmental problems (Wals, 2009). Researchers have commented that the EE concept was then transformed to ESD by giving more attention to economic and social issues (Sterling, 2004; McKeown and Hopkins, 2007).

- **ESD and EE partly overlap:** In some countries EE and ESD were acknowledged when the DESD was launched. Some governments have then implemented and developed both concepts (Wals, 2009). Although they have some overlap (both include environmental and economic issues), EE places the highest priority on environmental pillar and does not require profound change in societies (Barkin cited in Hesselink, 2000).

2.3.2 What is ESD?

Education is an interconnected element of sustainable development to enhance the ability of the world's residents to address sustainable challenges and create a more sustainable future (UNESCO, 2012). ESD is an approach that encourages all programmes and systems (both contents and methods) to take into consideration sustainable development (UNESCO, 2016a). ESD means more than teaching principles of sustainability, it is also related to all educational activities including planning, policy development, programme implementation, finance, curriculum, teaching, learning, assessment, and administration (UNESCO, 2012). DESD has started working on the implementation of ESD by focusing on 4 thrusts including:

- Improving access to quality basic education
- Reorienting existing educational programmes to address sustainability
- Increasing public understanding and awareness of sustainability
- Providing training to all sectors of the workforce (UNESCO, 2007)

UNESCO found that the definition of ESD is differently viewed around the globe as its interpretation requires local relevance. However, as the lead agency it has tried to define a set of characteristics that can be utilised as a starting point to the implementation of ESD (as illustrated in Table 3).

Table 3: Characteristics of Education for Sustainable Development (UNESCO, 2016a)

- is based on the principles and values that underlie sustainable development;
- deals with the well-being of all four dimensions of sustainability – environment, society, culture and economy;
- uses a variety of pedagogical techniques that promote participatory learning and higher-order thinking skills;
- promotes lifelong learning;
- is locally relevant and culturally appropriate;
- is based on local needs, perceptions and conditions, but acknowledges that fulfilling local needs often has international effects and consequences;
- engages formal, non-formal and informal education;
- accommodates the evolving nature of the concept of sustainability;
- addresses content, considering context, global issues and local priorities;
- builds civil capacity for community-based decision-making, social tolerance, environmental stewardship, an adaptable workforce, and a good quality of life;
- is interdisciplinary. No single discipline can claim ESD for itself; all disciplines can contribute to ESD.

UNESCO (2012) revealed that ESD is different from traditional education systems as it incorporates values of sustainability. Appropriate ESD learning does not only provide knowledge related to the TBL, but also skills, perspectives and values that encourage a change in behaviour (Arima et al., 2006).

HEIs play crucial roles in shaping the sustainable future as they generate knowledge which is transferred to societies by educating the future decision makers (Rieckmann, 2012; HEFCE cited in Cotton et al., 2009; Sibble, 2009) They are intended to be the places that provide freedom to think and encourage creativity (Moore, 2005). Universities are expected to build awareness, influence learners' attitudes (or values), and facilitate the development of the knowledge and skills required to shape a more sustainable future (Buckler and Creech, 2014). According to the DESD report, *"universities must function as places of research and learning for sustainable development*" (Arima et al., 2006). Many HEIs have acknowledged and

agree to integrate ESD into their curriculum as evidenced by the number of universities which have signed the Talloires Declaration.[2] The declaration was initially adopted in 1990 and has been agreed by over 400 leading HEIs from 50 countries in 2008 (ULSF, 2008).

Although ESD has been widely integrated into the HE system, a UNESCO white paper (2012) indicated the lack of appropriate learning approaches. It shows that many formal institutions focused on developing knowledge and skills and gave little consideration to integrating values that are a key to successful sustainable development.

2.3.3 The need to integrate value of sustainability into education system

As presented in the previous section, ESD aims to supply learners with knowledge, skills, and values required for sustainable development. However, UNESCO (2012) found that many HEIs only focus on developing knowledge and skills. Gross and Nakayama (2010) suggest that exclusive focus on knowledge and/or skills does not comply with the objectives of ESD that propose to encourage social transformation. Addressing sustainable challenges requires responsible decisions that respect others, so one has to select the best option that can balance the TBL. Wals (2009) underlines the need to integrate values inherent in sustainable development into education as it can encourage the deep change in behaviour that leads to a more sustainable society. Integrating the values into learning aspects is considered as an overall goal of DESD (2005-2014) and also distinguishes ESD from traditional education (UNESCO, 2012).

Tradition education systems focus on the economy and reinforce the values that encourage learners to consume rather than conserve (Sterling, 2001). This influences current decision makers to exclusively consider the economic pillar and rely on business benefits. An example drawn from UNESCO (2012), illustrates this: an old-fashioned steel mill mainly focused on generating profit without caring for workers

[2]It is an action plan and agreement to disseminate and support integrating sustainable development in higher education (Wright, 2002).

injured in similar accidents. The mill also lacked effective waste management and caused air and water pollution.

As seen in the example above, values and attitudes are a major influence to achieve sustainable development as they directly affect the way people behave with towards others, the environment, and other species (UNESCO, 2010; Matsuura, n.d.). UNESCO's Bonn Declaration (2009 cited in Newman 2011) also emphasises that ESD is based on values of justice, equity, tolerance, sufficiency and responsibility. Each country, cultural group and individual is required to acquire competency that allow learners to understand their own values and compare them in the context of sustainable development (UNESCO, 2012). The Earth Charter (1992) highlights that the world's residents are required to declare their responsibility to one another, to the greater community and to future generations. The Charter's declaration is acknowledged as one of the best learning resources for understanding sustainability values (UNESCO, 2016b). It is a framework that contains ethical principles for building a fair, sustainable, and peaceful society (UNESCO, 2016b). Its aim is to influences all people on the earth to be more interdependent and have a shared responsibility for the well-being of all species in the planet (Earth Charter web, 2016). Table 4 presents the Earth Charter principles that are grouped into four pillars.

Although the need to integrate the values inherent in sustainability has been widely promoted during the DESD, many HEIs still give less consideration to enabling learners to acquire these values (UNESCO, 2012). One of the main barriers to integrate values is that traditional teaching approaches are not appropriate to ESD learning (see Section 2.3.4).

Table 4: The Earth Charter principles (Earth Charter, 1992)

I. Respect and Care for the Community of Life
1. Respect Earth and life in all its diversity.
2. Care for the community of life with understanding, compassion and love.
3. Build democratic societies that are just, participatory, sustainable and peaceful.
4. Secure Earth's bounty and beauty for present and future generations.
II. Ecological Integrity
5. Protect and restore the integrity of Earth's ecological systems, with special concern for biological diversity and the natural processes that sustain life.
6. Prevent harm as the best method of environmental protection and, when knowledge is limited, apply a precautionary approach.
7. Adopt patterns of production, consumption and reproduction that safeguard Earth's regenerative capacities, human rights and community well-being.
8. Advance the study of ecological sustainability and promote the open exchange and wide application of the knowledge acquired.
III. Social and Economic Justice
9. Eradicate poverty as an ethical, social and environmental imperative.
10. Ensure that economic activities and institutions at all levels promote human development in an equitable and sustainable manner.
11. Affirm gender equality and equity as prerequisites to sustainable development and ensure universal access to education, health care and economic opportunity.
12. Uphold the right of all, without discrimination, to a natural and social environment supportive of human dignity, bodily health and spiritual well-being, with special attention to the rights of indigenous peoples and minorities.
IV. Democracy, Nonviolence, and Peace
13. Strengthen democratic institutions at all levels, and provide transparency and accountability in governance, inclusive participation in decision-making, and access to justice.
14. Integrate into formal education and lifelong learning the knowledge, values and skills needed for a sustainable way of life.
15. Treat all living beings with respect and consideration.
16. Promote a culture of tolerance, nonviolence and peace.

2.3.4 Reorientation of ESD learning in higher education

UNESCO and other educators (e.g. Sterling, 2010; Burns 2011; Elliott, 2010; Cress 2003) agree that the traditional approach that has been widely used in education systems is not appropriate to the learning and teaching of sustainable development. ESD has been then proposed to enable educational institutions to reorient their education systems (UNESCO, 2012). This section explains why this is required to achieve sustainable development through the comparison between traditional approaches and ESD as summarised in Table 5.

Table 5: the comparison of traditional education systems and ESD (adapted from Sterling, 2004; Van den Bor et al. 2000)

Traditional education	ESD
Transmissive approach (Lecture-centred)	Transformative approach (Student-centred)
Emphasis on cognitive and psychomotor domains	Require to engage students through all three domains and focus on affective domain
Focus on input	Focus on output
Reductionism	Trans-disciplinary
Economy	All sustainability spectrums

2.3.4.1 Transmissive and transformative approach

The traditional education system has been dominated by transmissive approaches that are not appropriate to sustainability learning (Wals, 2012; Sterling, 2001). This traditional approach focuses on preparation of teaching content that will be transmitted to learners who are considered as empty containers that will be filled with knowledge by lecturers who are experts (Pratt, 2002). Thus, the content oriented learning goal is to master the selected subjects, emphasising accumulating information, facts, contents and skills (Moore, 2005). The transmissive approach is considered as lecture-centred; lecturers will deliver knowledge and/or thinking based on their experience (Pratt, 2002), and little time is allocated for discussion (Moore, 2005).

Although this 'taken-for-granted' approach allows students to obtain the required information and pass their exams, it usually fails to engage students' motivation

(Gini-Newman, 2010). ESD requires an educational approach that can empower learners to profoundly change their behaviour and make contributions to sustainable development (McKeown and Hopkins, 2005). A transformative approach is widely acknowledged as a more appropriate way to achieve ESD as it allows learners to shift their perception and change the way they live (Sterling, 2011). Mezirow (1997 in Moore, 2005) considers transformative learning as a process of transforming the frame of reference (habit of mind, mind-set, and perspective), which can be shifted through critical reflection of bias and assumption (Moore, 2005). This can be achieved by asking questions and understanding how previous beliefs were constructed based on prior experience (Taylor, 1998 p5). Student-centred teaching is a core of transformative learning, lecturers only play a role in building a learning environment that encourages learners to be critically reflective and re-examine their beliefs (Haber-Curran and Tillapaugh, 2015). The student-centred approach also allows learners to merge their experience within the learning process and see themselves differently (O'Neill and McMahon, 2005).

2.3.4.2 The use of three learning domains

Although the three learning domains of Bloom (cognitive, psychomotor and affective domains) have been officially recognised since 1956 (Bloom et al., 1956). Sterling (2011) and UNESCO (2012) found that most traditional educators only focus on the cognitive and psychomotor domains. While achieving ESD requires engagement in all three domains (Segalas et al., 2010; Sipos et al., 2008). Chalkley (cited in Shephard, 2008) suggests that ESD expects learners to understand sustainability issues, with their heads, to acquire skills that enable them to act sustainably if they wish, with their hands, and have attitudes that influence them to behave sustainably, with their hearts. Sipos et al. (2008) introduce the ESD learning framework that demonstrates the use of these three learning domains as presented in Figure 5.

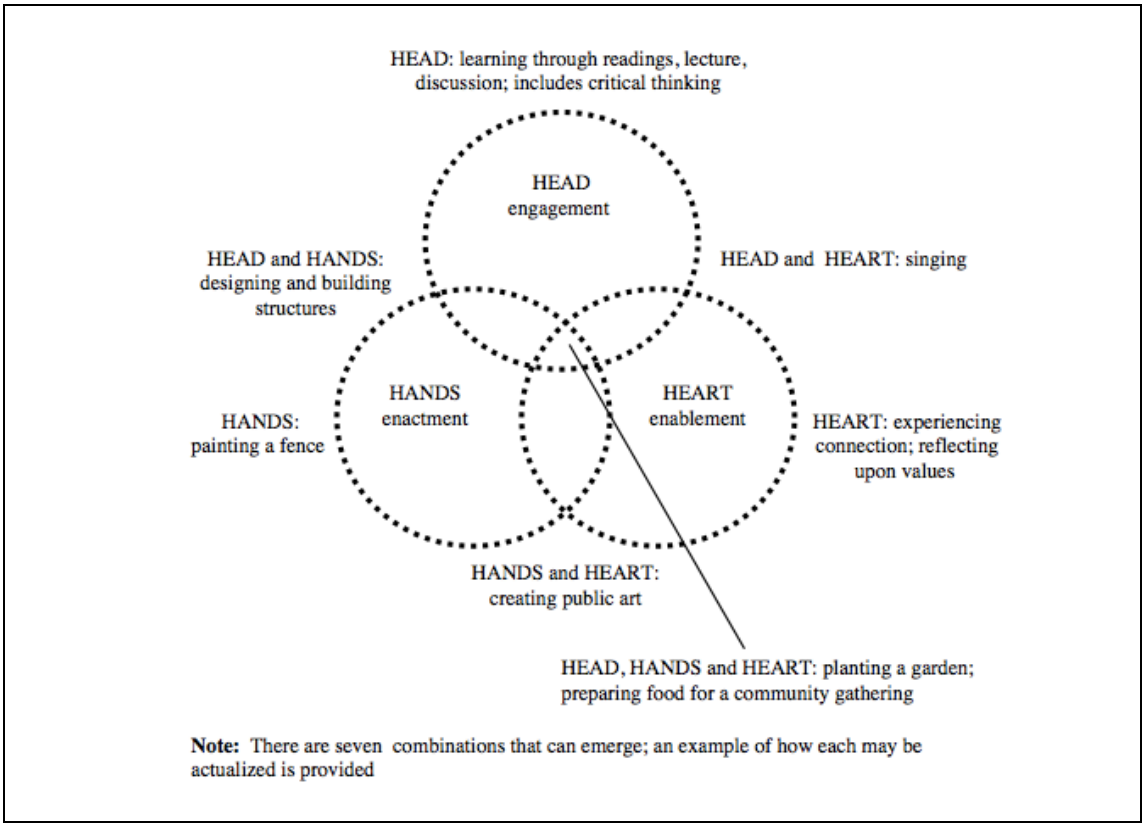


Figure 5: The framework of transformative sustainability learning (TSL) that was built up from Bloom's taxonomy (Sipos et al., 2008; p.75)

The framework can be utilised as a pedagogic landscape that categorises existing learning strategies, through the use of the three learning domains (Sipos et al., 2008). The comparison between transmissive and transformative approaches discussed in Section 2.3.3.1 can be used as an example. Transmissive approaches promote the development of knowledge and/or skills that engage students through cognitive (head) and/or psychomotor (hands) domains. While, transformative approaches extend the learning scope by including self-reflection that is an activity in the affective (heart) domain. During the DESD period (2005-2014), many publications related to ESD have been published and teaching strategies have been introduced that can be applied to ESD implementation. Example of the strategies are back-casting, service learning, action learning (more details about teaching strategies will be discussed in Section 2.6.2).

Wals (2009) suggests "there *is not one correct interpretation and the use of ESD"* (also strategies) due to its complexity. Learning and teaching strategies need to be applied in locally relevant and culturally appropriate ways (UNESCO, 2012). Each group of learners has its own learning context and culture but all of them are expected to achieve the same goal. ESD aims to enable learners to acquire the knowledge (head), skills (hands) and values (heart) required to achieve sustainable development (Arima et al., 2006). The TSL model presented in Figure 5 allows educators to understand their current ESD activities to enable them to discover how they can develop their current activities through balancing the use of three learning domains (head, hands, heart) (Sipos et al., 2008).

Among the three learning domains, the heart domain is considered as a key to the success of ESD as it is directly associated with embedding sustainability values which is the core to achieving sustainable development (as discussed in Section 2.3.2). Shephard (2008) also highlights that ESD is about pursuing affective outcomes. Along with its direct benefits in integrating the values, achieving outcomes in the affective domain also helps learners to gain outcomes in other domains.

2.3.4.3 Focusing on input or output

As discussed in Section 2.3.4.1, traditional education systems rely on didactic teaching that mainly focuses on preparation of learning contents (input). However, it seems impossible to prepare learning content for ESD, as addressing sustainable development issues requires specific solutions. Wals (2009) reveals that there is no one-size-fits-all approach for sustainable development due to its complex nature. Sustainable challenges in each region, country, group of people is diverse, based on their environmental, cultural, and political contexts (UNESCO, 2012).

Moreover, ESD is broad as it looks beyond traditional education. Firstly, the traditional education system predominantly focuses on enabling learners to conquer economic challenges (Sterling, 2001) while sustainable development proposes to address the interconnection of TBL (economic, environment and social aspects) (UNpresskits, 2015). Secondly, traditional education relies on a reductionist approach while ESD promotes trans-disciplinary learning. The traditional education

system believes that understanding all elements of a system will allow learners to have an insight into the whole system. Thus, patterns of learning in formal education traditionally influence learners to be specialists in their own disciplines (Hjorth and Bagheri, 2006). Although specialising in a certain discipline allows obstacles to be overcome in particular fields, it leads humanity to be less prepared for the interconnection between TBL that is required to achieve sustainable development (Sterling, 2001).

As demonstrated in the discussion above, it seems impossible to prepare learning content that covers this broad topic. Output approaches or competence based learning has been introduced and is widely acknowledged as a more appropriate way to achieve ESD learning. Competence-oriented approaches stress on enabling students to acquire abilities that are required for problem solving and social actions (output) (Sleurs, 2008; De Hann, 2006). In other words, students will be faced with real world problems and expected to address them (Wals, 2012). UNESCO (Wals, 2012; Tilbury 2011) and other educators (Thomas, 2009; Moore, 2005; Sipos et al., 2008) agree that the education approach for ESD should switch from the input to output. The output approach enables HEIs to improve learning and teaching quality. Lecturers can effectively assess the syllabus though specific learning outcomes that are defined for their courses. In addition, the output approach improves the way learning content is used and makes it more compatible with ESD. It allows students to select their own learning topic based on their self-interest and previous experience; the use of flexible content allows higher levels of attention and progress in improving skills (Weinert, 2011). The following sections will discuss how learning outcomes can be classified (Section 2.3.5) and which are required for ESD (Section 2.4).

2.3.5 Classification of Learning Outcomes for ESD

The process of setting learning outcomes is necessary for ESD as it provides a framework that can guide educators to select teaching strategies and appropriate content (UNESCO, 2007;). The term *"learning outcomes [refers to] explicit expectations of what a student will be able to do as a result of completing a learning activity"* (Jenkins and Unwin, 1996). Attempts to identify learning outcomes have been demonstrated through a number of studies in the field of ESD (e.g. Wiek, 2011, Barth, 2007; de Hann, 2006). Various sets of objectives have been developed and applied in HEIs. Examples are shown in Table 6.

Table 6: an example of a set of learning outcomes (Svanstrom, 2008)

Examples of learning outcomes
- An ability to establish the connections to the triple bottom line (TBL) and other sustainable development (SD) dimensions that influence learners' knowledge discipline. - An ability to apply assessment criteria or sets of principles or available tools related to sustainability in learners' disciplines. - The systemic education needed to understand the impact of learners' disciplines solutions or actions in a TBL context. - For disciplines that prepare engineering professionals: An ability to design processes, products and components taking into account the life cycle analysis using the appropriate SD dimensions constraints. - For disciplines that prepare professionals that provide or design services: An ability to design services that take into account the connectedness and implications for those services as related to the SD dimensions constraints. - An ability to implement the needed actions to foster sustainability in learners' professional and personal life.

Each HE course establishes a set of learning outcomes for building knowledge , according to the different nature of disciplines. However, a consistent feature is the intention to develop awareness of sustainable issues and influence change in society (Shephard, 2008). The learning outcomes of ESD should therefore include not only knowledge but also the values that can influence change in behaviour (Chalky, 2006). Graduating students are required to understand the principles of sustainability, acquire skills to shape a more sustainable future and have the willingness to take the actions (Shephard, 2008). As previously discussed, Bloom (1956) classified the

learning outcomes into three domains, based on their distinctive nature as discussed below:

2.3.5.1 Cognitive domain

Lecturers are familiar with the use of the cognitive domain because the traditional education approach has focused on the development of skills in this domain (Sterling, 2011). Learning outcomes in this group refer to human knowledge and the development of intellectual skills (Bloom, 1956). The domain focuses on the way learners acquire, process and utilise knowledge (Wiek et al., 2011). Knowledge (cognitive domain) is primarily required for ESD as the concept of sustainability is quite broad and complicated. Along with containing three different elements (economic, environment, and society), sustainability information is also varied and based on the nature of specific disciplines (Dawe et al, 2005). Broad knowledge from different disciplines enables the critical analysis of current situations and identifies a more appropriate solution for a sustainable future (Shepard, 2008).

Moreover, previous research (Mawle et al., 2010; Moore, 1994) has identified that the lack of understanding on sustainability issues is one of the most common barriers that obstruct the implementation of sustainable development; and therefore contributes to unsustainable behaviour (Esa, 2010). Along with the objective related to knowledge, some authors have indicated that the learning domain can refer to awareness of ecological and social concerns, such as environmental degradation, wasteful consumption and poverty.

2.3.5.2 Affective domain

The affective domain involves learning objectives that relate to learners' emotions, including feelings, values, and attitudes (Segalas et al, 2009). It has been shown in previous research that educational institutions are one of the main contributors to change and develop student's attitudes (Shephard, 2008; Drayson, 2012; Kraft et al., 2011). Many researchers (e.g. Elliott, 2010; Segalas et al, 2009; Sipos 2008) in the field of ESD acknowledge that the integration of learning outcomes in this domain is necessary to accomplish its learning and teaching in higher education.

Firstly, many students currently engage with a surface learning approach that relies on memorising; they only aim to remember and accept required information for purposes of exams (Cureton and Cousin, 2012; Sterling, 2001). Affective domain can influence students to shift from a surface learning approach to a deep learning approach (Cureton and Cousin, 2012). Students will appreciate the value of subjects and have more intention to learn, which leads to the better knowledge acquisition and performance of students (Lublin, 2003). In summary, a positive outcome on the affective domain is a key to successful learning objectives in the cognitive domain (Boyle et al., 2007). Table 7 shows how the affective domain contributes to learning and teaching.

Table 7: The connections between affective and cognitive domains (Entwist 1991 cited in Boyle et al., 2007).

Deep approaches to learning	Surface approaches to learning
• Intention to understand material for oneself • Interacting vigorously and critically on content • Relating ideas to previous knowledge/experience • Using organizing principles to integrate ideas • Relating evidence to conclusions • Examining the logic of the argument	• Intention simply to reproduce parts of the content • Accepting ideas and information passively • Concentrating on purpose or strategies in learning • Not reflecting on purpose or strategies in learning • Memorizing facts and procedures routinely • Failing to recognize guiding principles or patterns

Secondly, ESD necessitates a change in attitude because it will direct future decision makers to take action and influence change in behaviours that contribute to sustainability (Wals, 2012). The affective domain can encourage willingness to revise attitudes and then lead to the change required (Elliott, 2010; Krathwohl, 1984).

Although the learning outcomes in this domain are necessary for changing toward sustainability, HEIs have struggled or avoided integrating them into the curricula.

According to Shepherd (2008), many lecturers do not include affective outcomes into their lessons because they are perceived as being impossible to assess within the short periods of any learning programmes. Lecturers are also uncomfortable about charges of indoctrinating, as issues associated with the affective domain are considered as private rather than public (Shepard, 2008).

2.3.5.3 Psychomotor domain

The psychomotor domain represents learning outcomes as associated with developing physical and motor skills (Harrow, 1972). Although it is included in the three learning domains of Bloom, some publications have only focused on the other two domains. Geertshuis (2009) claims that this domain is not associated with the development of decision making for sustainability. However, evidence has shown that psychomotor skills provide both a direct (i) and indirect (ii) contribution to sustainable development. Firstly, many studies have not only included the skills previously mentioned but also abilities to cooperate, and communicate with stakeholders in different disciplines (Alampei, 2007; Remenyi, 2009; de Haan, 2006; Wiek et al., 2011). The additional skills are essential to achieve sustainable development that requires collaboration from various group of people (UNESCO, 2010). Secondly, improving psychomotor skills potentially enhances practitioners' knowledge in some disciplines. Deliberate skill practice with attention and rehearsal allow learners to develop more complex knowledge (Brabeck, 2006). The UNEP white paper (2006) states that learning-by-doing facilitates learners to develop the ability to organise and analyse.

In summary, all three learning domains are mandatory to achieve the goals of sustainable development. Previous studies (Sipos, 2008) have underlined the importance and advantage of classifying learning objectives into three domains. This classification enables educators to enhance their teaching plans to select more appropriate strategies and teaching content.

2.4 Competencies for ESD in higher education

The term 'competency' has been broadly used in the education field but it has still no precise definition (Barth, 2007). However, De kraker (2007) has attempted to

define it through pulling out the common elements from educational research. He defines the term 'competencies for sustainable development' as *"the combination of knowledge, skills, and attitudes that enable graduates to effectively contribute to transition processes towards a (more) sustainable society"* (De Kraker, 2007; p. 107). As the output approach is becoming more accepted in the educational field, many academic publications have identified and created various sets of key competencies in sustainability. However, most authors only presented lists of competencies and did not show the relationship between competencies. This section presents the key competencies based on the work of Wiek et al. (2011) who demonstrated five competencies in a format of a problem-solving framework as shown in Figure 6.

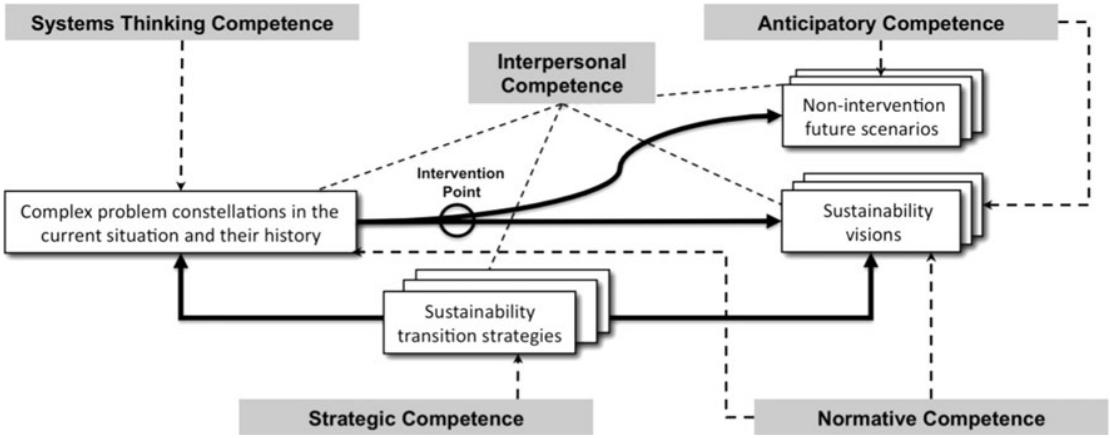


Figure 6: The five key competencies in sustainability (Wiek et al., 2011)

Figure 6 shows how the competencies are related through the process of sustainable development intevention. The selected competencies are normative, system thinking, anticipatory, strategic, and interpersonal. Along with these five key competences, this section also introduces critical competence as it is considered as a required skill for achieving sustainable development (UNESCOBKK, n.d.). Wiek et al. (2011) did not include it in the set of competencies as they believe that it has already been acknowledged in higher educaiton.

2.4.1 Normative competence

Acquiring basic knowledge about social science, ecology, and humanity is a prerequisite to understanding the principles of sustainable development as the

concept encompasses three different elements: economic, environment, and society (McKeown, 2003). Grunwald (2007) states *"knowledge is an essential input to make reasonable and robust decision[s] about shaping strategies and adequate measures".* For example, it can help policy makers to know which initiatives should be developed, maintained, or rejected to sustain the system (Wiek et al., 2011). UNESCO (2016a) and McKeown (2002) also state that knowledge is required to identify sustainability goals and achieve sustainable development. Based on the literature review, sustainable development knowledge has been built and transferred to societies in different forms and levels. The Brundtland Report is a classic publication that provides the description of sustainability principle. This basic information allows decision makers to improve basic decisions and gauge the progress of sustainable development but only in the cases that have clear goals and explicated measures (Hammond et al., 1995). The rapid development of technology and limited natural resources make human communities more complicated. Hence, various solutions and tools have been developed to achieve sustainable development in more complex issues. Developing indicators is another form of using knowledge (Arima et al., 2006). It allows decision makers to develop more effective solutions as they can provide guidance in different ways: translating physical and social science knowledge into manageable units for decision makers, indicating effectiveness of the past solutions, and providing early warning to prepare problem-solving solutions (UN, 1995; 2007). Various patterns of knowledge have been produced to contribute to the sustainable future and categorised based on their functions, such as providing knowledge based information, assessing and judging, and ranking of sustainability weak spots (Grunwald, 2007). Wiek et al. (2011) have also identified other forms of using knowledge: values focused thinking, ethical thinking, and orientation thinking, collected from relevant literature. Grunwald (2007) stresses that the effective set of knowledge for sustainability needs to comprise all three functions: (1) explaining cause and effect chains to understand all actions; (2) identifying criteria to diagnose and prepare problem-solving solutions; (3) matching the appropriate knowledge to actions. The normative competence can be built through acquiring different forms of knowledge and enables possessors to *"collectively map, specify, apply, reconcile, and negotiate sustainability values,*

principle, goals, and targets" (Wiek et al., 2011; p209). The competence also involves skills to assess sustainability issues and create problem-solving solutions (Wiek et al., 2011).

2.4.2 System thinking competence

Humankind has struggled to survive in the world as it is becoming more complicated and difficult to understand (Srachan, 2011). A reductionist approach has traditionally been employed to clarify complex issues. The general consensus of people in modern science is that understanding all elements of a system will allow them to have an insight into the whole context (Hjorth, 2006). Thus, patterns of learning in formal education have shifted from multidisciplinary ones to those that specialise in particular areas, as previously mentioned. This leads them to be less prepared for interconnection. Problem solving solutions are decided without consideration of other stakeholders in the life cycle and possibly generate greater problems. For example, use of pesticide can help farmers to enhance their food production but the residues on food can cause many health problems (Strachan, 2011). Researchers (Bawden, 1991; Capra, 1993; Hjorth, 2006; Srachan, 2011) underlined how learners cannot understand a whole system through investigating all parts of the structure individually because new elements called 'relationships' will emerge when all parts are combined. The researchers then suggest that people are required to break their mind-sets and shift from the traditional approach to system thinking which can effectively facilitate them to discern the problems in the interconnected world and enable them to move towards a more sustainable future. System thinking is defined as the ability to collectively comprehend the whole system including all elements and relationships that emerge within the complex whole (Senge, 1992). The competence is considered to be one of the core ones for ESD as it allows learners to identify and analyse interdependencies across the economic, environmental, and societal domains of sustainability (Dawe et al, 2005). This enables people to clarify complex issues and select the most appropriate actions that provide less negative impacts (Ponto, 2011). Consequently, the term has widely appeared in the literature related to ESD, and sometimes referred to as holistic thinking, and interconnected thinking (Wiek et al., 2011).

Hjorth (2006) found that system thinking is frequently included in sets of learning outcomes for sustainability modules at the undergraduate level. In addition, Svanstrom et al (2008) divides system thinking into two skills, analytic thinking that enables learners to break systems into constituent parts while synthetic thinking allows them to discern cause and effect chains that combine all properties together.

2.4.3 Anticipatory competence

It is becoming more difficult to survive in the age of globalisation as people are now operating in the connecting world that is complex and rapidly changing (Sheate and et.al, 2007). Thus, decision makers are required to envision the future changes and prepare solutions to deal with them (Masini, 2000 cited in Kelly, 2004). Although the future cannot be precisely predicted and imposed, people can anticipate it and try to find solutions to live with the changes (Wayman, 2009). Kelly (2004) believes that foresight thinking enables people to influence the future as it facilitates them to envisage it and prepare appropriate actions in the present. It also allows the decision makers to creatively enhance their policies, particularly those that are related to the development of people, the economy, and ecology. Rohrbeck (2012) and Lang (cited in Duinker, 2007) concluded that foresight thinking normally has two main functions: reducing risk that may happen by preparing the solution in advance and facilitating decision makers to creatively develop strategic plans to reach their goals.

The concept of foresight thinking, also referred to as future thinking and anticipatory competence, is widely accepted in ESD research as it is compatible with the characteristics of sustainable development that calls for long-term orientations and envisioning the future to mitigate harm from human activities (Wiek et al., 2011). The future thinking is more than forecasting, it embraces rigorous methods to identify long-term trends and find alternative scenarios for the future (Wiek et al., 2011). Many approaches have been developed to facilitate users to achieve foresight thinking. The scenario technique is predominantly used as an effective tool to enable users to envision the future (Rohrbeck, 2012; Schoemaker, 1995). Duinker (2007) underlined that scenario building is not prediction, but it involves systemic methods to study possible future situations. It enables users to think beyond the frontiers of reality and help them prepare possible problem solving solutions by asking them to

be open-minded and consider all uncertain factors including what might be considered as impossible situations (Schoemaker, 1995).

2.4.4 Strategic competence

According to findings from the literature review, incorporating concepts related to sustainable development into the product design/manufacturing industry is becoming more widespread. A number of sustainable design activities have been carried out, which can be used as case studies for the integration of other projects. However, (Tilbury et al., 2007) found that there is no one-size-fits-all approach as each country has its specific circumstances. Therefore, the existing problem solving solutions from these product development cases could not be directly adopted due to the difference in context and rapid change.

Sustainable product designers are then required to acquire strategic competences as they allow them to apply sustainable design theory and effectively integrate it into their design projects. The competences have been discussed and presented through the different terms including ability to link knowledge to action, competence in planning and implementation, co-construction of knowledge and practical solutions (Wiek et al., 2011). Strategic competence is an ability to appropriately select the existing problem solving solution or theory for planning (designing) to deal with the sustainability issues that are unique and rapidly changing (Grunwald, 2007; de Hann, 2006; Bammer, 2005). It also involves the ability to calculate side effects and possible negative impacts that might emerge from the selected actions (Wiek et al., 2011). This competence can be encouraged through studio-based modules that provide students opportunities to practice linking knowledge to action (Green and Bonollo, 2003). In other words, the studio type enables students to experience integrating sustainable design principles into their design projects.

2.4.5 Interpersonal competence

Many researchers (de Hann, 2006; Warburton, 2003; Crofton, 2000) conclude that interpersonal competence is one of the required skills to achieve the implementation of sustainable development. This competence has been widely discussed as collaborative, participatory, civic, and interpersonal competence (Wiek

et al., 2011). The integration of concepts related to sustainability requires cooperation from people from different disciplines (UNECO, 200x). It would be impossible for one expert to have a wide range and deep knowledge that is required to address all sustainability issues (de Kraker, 2007; Tormey, 2008). Therefore, sustainable development requires cooperation of experts from different fields. Working in a multi-disciplinary context is a challenge and can cause conflict between the team members as they have different educational backgrounds and opinions (Tormey, ibid). For example, in one case, a government called in experts from different fields to reduce a litter problem; many people kept throwing away rubbish in public spaces. A sociologist identified that residents were lacking in a sense of ownership of the space while, an engineer suggested the government should integrate a waste management system (Tormey, ibid). To reduce the problem of disciplinary-bound thinking and encourage better team working, the members need to be open-minded and acknowledge the diversity of opinion (de Kraker, 2007). Researchers (Tormey, ibid; Warburton 2003) agree that education should shift from a traditional approach to an interdisciplinary one. Tormey (ibid) suggests learners consider working with people from other disciplines and/or work cultures as this can influence learners' attitudes and enable them to understand the value of other professions. In addition, interdisciplinary studies provides students with a better understanding of the complexity of real-world problems (Eagna, 2002). Wiek et al. (2011) conclude that interpersonal competence should include team-working skills, such as communication, deliberation, and negotiation. To sum up, it is an ability to facilitate team cooperation (Wiek et al., 2011) and work across disciplines (de Kraker, 2007).

2.4.6 Critical thinking competence

One of the main challenges to address sustainability issues is to identify appropriate solutions. A number of knowledge and problem solving solutions have been created and successfully implemented. As previously mentioned, although many show proof of success in addressing sustainability problems, the decision makers cannot just adopt the effective solutions as there is no one-size-fits-all approach to sustainable development; each context, depending on time period, culture, and environment, has its own sustainability issues (Tilbury et al., 2007). Successful implementation in one community might not be effective in other places.

Critical thinking competence enables learners to achieve sustainable development interventions as it facilitates them to select appropriate solutions. This thinking style is widely acknowledged as a one of the key competences for ESD as it enables the decision makers to have a clearer view of current situations and understand existing sustainable solutions (Dawe et al, 2005; Rieckmann, 2012). Critical thinking is a process that enables learners to recognise different ways to understand the world though viewing it from different perspectives (Bourn, 2014). The competence can be simply defined as an ability to think with a higher level of reasoning and in a non-biased way (Tilbury and Wortman 2004; Halpern 1998; Elder and Paul, 1994). Many people may not be aware that they have built mind-sets through absorbing information from biased-sources such as talking with friends, watching television, and browsing the internet (Tilbury and Worman, 2004).

Critical thinkers should have fair-minded, diligent, inquisitive attitudes to seek proof of facts (Giancarlo and Facione 2001;Ozturk, Muslu, & Dicle, 2008 cited in Thomas, 2009). These characteristics will then enable them to understand the opinions of others and how their experiences were built (McMahon, 2013).

The diagram in Figure 7 clarifies how critical thinking helps learners to understand complex problems and/or issues.

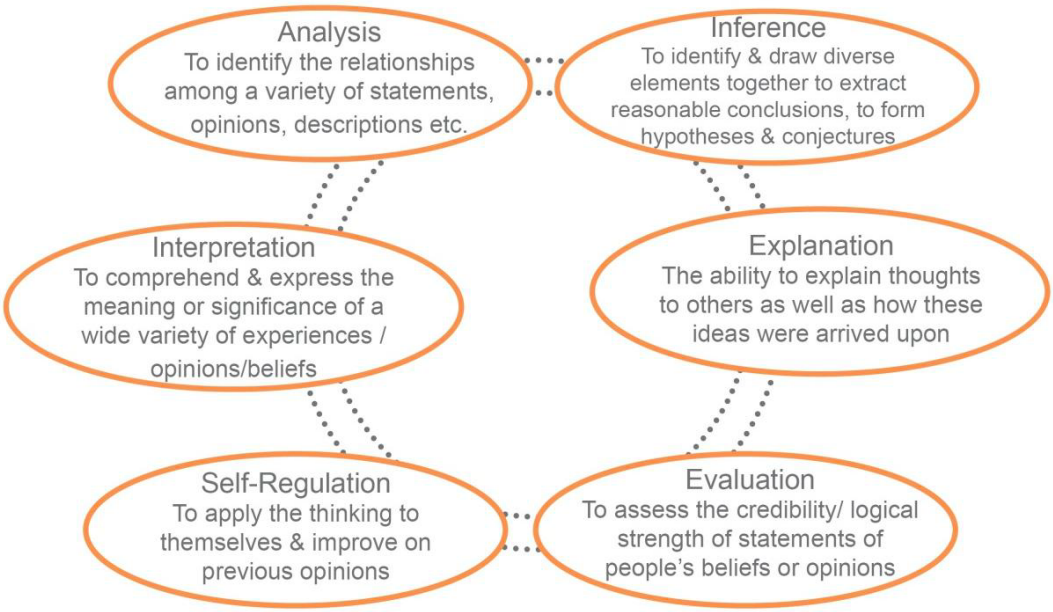


Figure 7: Skill of critical thinkers (Facione, 2009 cited in McMahon, 2013).

Facione (2009) implies the need to reorient education systems, to enable learners to acquire critical thinking skills. This requires learning processes that are student-centred. Learners are expected to acquire information that is generated from their observations, experience, reflection, reasoning and active questioning (Facione, 2009).

2.5 Barriers to implement ESD into higher education

As previously discussed in Section 2.3 and Section 2.4, a more effective learning approach has been developed. Transformative learning and identifying outcomes (output) allow educators to enhance teaching capability and contribute to the integration of ESD into HE. However, the implementation of ESD is still obstructed by a number of barriers that have been identified in several previous studies. This sub-section presents the four common barriers that regularly appear in most research studies (Dawe et al., 2005; Gross, 2009; Stering, 2011).

The first barrier is the perceived irrelevance of ESD by academic staff. Dawe et al, (2005) along with other authors (Sterling, 2013; Cotton et al. 2007) have agreed that lecturers' perceptions of ESD can cause obstructions. Embedding sustainability learning content can be easily done in some subject disciplines (e.g. engineering, environmental science) as the topic is directly related to the fields. However, some

subject disciplines do not have a concrete linkage with sustainable development and it is difficult to integrate the content into their curricula (Dawn, 2005; McKeown and Hopkins, 2007).

The second barrier is lack of staff awareness and expertise. UNICEF (2013) along with others indicate that the shortage of lecturers with qualifications in sustainable development is one of the significant barriers in achieving ESD. Symons (2008) found that the barrier partially originates from the lack of time and priority. The problem and its root can be reduced through launching policies that facilitate and stimulate lecturers to acquire the knowledge (Cheadle et al., 2004).

The third barrier is crowded curricula. Sustainable development should be taught to all groups of learners as it can shape them to be responsible citizens (UNESCO, 2010). However, it is only considered as an optional content and is not given priority. Dawe et al. (2005), Holmberg et al. (2008) and Fadeeva (2010) found that most academic disciplines already have crowded curricula and found that it is difficult to embed additional content.

The last barrier is a lack of institutional drive and commitment. Integrating sustainability into the curricula requires a clear direction to influence staff to change and take action. Management levels of HEIs are responsible for providing an initial push and launching policies that encourage action (Mohamad, 2001). However, many academic and white papers have found this lacking and have suggested a set of policies that aim to contribute to ESD (UNESCO, 2008; HEFCE, 2014).

As discussed in this section, there are inter-connections between each barrier both directly and indirectly. For example, the lack of insight into sustainability leads lecturers to feel that the topic is not relevant to their subject disciplines. The findings from the literature review imply that enhancing teacher education is one of the appropriate solutions to reduce these problems as they are all directly related to lecturers. In addition, Down (2006) and Hopkins & McKeown (2005) have indicated that teacher education is expected to be a key change agent for implementing

sustainable development as it potentially brings change in the education system. Teachers are required to be aware of their important role in implementing ESD (Holmberg, 2012) as they are not only expected to play a key role in disseminating sustainability information to learners but also inculcation of values to the future citizens. Equipping (both in-service and pre-service) teachers with appropriate knowledge skills, and values is then a fundamental step and required to address unsustainability issues (Wals, 2012; Sleurs, 2008).

2.6 Resources that can facilitate the implementation of ESD

ESD proposes to enhance traditional education to be more compatible with sustainable development through reorientation of the education system's both learning content and methods (Section 2.3.2). This section presents the previous works that has attempted to facilitate the reorientation by dividing them into two groups: sustainable design learning materials (focusing on content) and ESD teaching strategies (focusing on method).

2.6.1 Sustainable design learning materials

Designers require information sources to facilitate the development of sustainable products (Lofthouse, 2001; Argument, 1998; Bakker 1995), but Dewberry (1996) found that designers had been given information that is too technical. Consequently, information provision materials were specifically developed for the design profession. Along with the appropriate information, some of the materials have been developed further and are more effective. The key to success is taking the learning culture of industrial/product designers into account. The previous research projects (Vitoria-Uribe, 2009; Bhamra and Lofthouse, 2003; Lofthouse 2001) found that the design profession has a specific way to acquire knowledge. Lofthouse, (2006) also discovered that many of the existing tools have not been widely used due to the inappropriate presentation style; information is often presented in a text format that is time-consuming and cannot comply with the needs of designers. Designers prefer to acquire information through creative presentations that maximize the use of graphics (Lofthouse, 2006). Bhamra and Lofthouse (2003)

present a framework that can contribute to the knowledge transfer of sustainable design as illustrated in Figure 8.

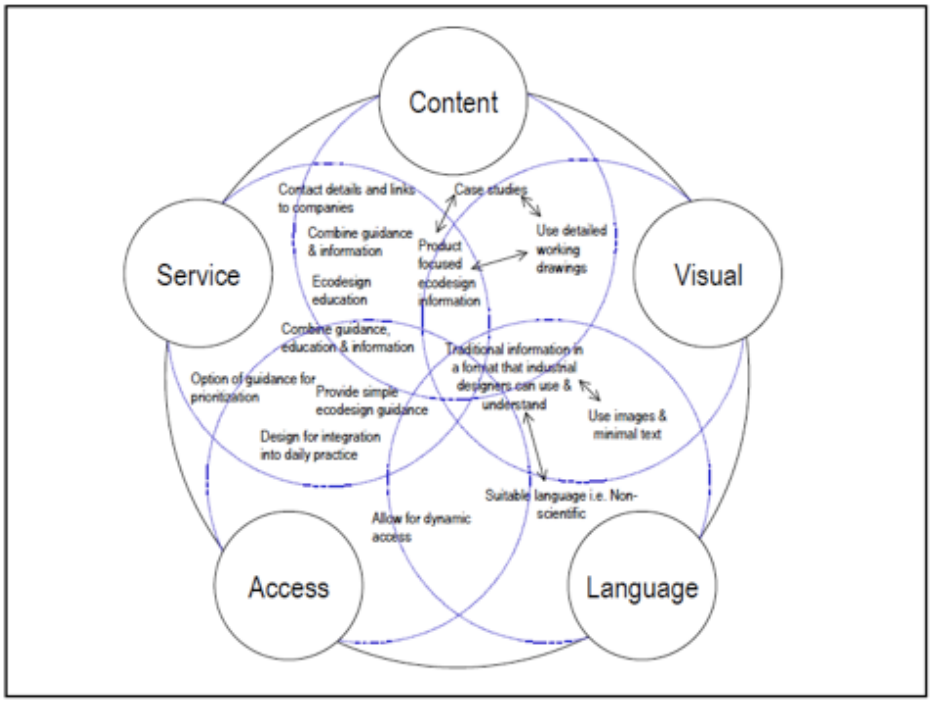


Figure 8: A holistic framework for industrial design focused eco-design tools (Bhamra and Lofthouse, 2003)

The model in Figure 8 shows important elements that are required for the development of a sustainable design tool. Moreover, Victoria-Uribe (2008) identifies desirable and non-desirable characteristics of sustainable design tools based on this framework, as shown in Table 8.

Table 8: The Desirable characteristics of eco-design tools (Victoria-Uribe, 2008)

Desirable Characteristics	Non-desirable Characteristics
- High quality of information - Easy to use - Concise/Brief texts - Guidance/Map/Index - Use of appropriate graphic - Offers tools - Offers examples/case studies - Includes regulation - Low cost - Basic technique requirement - Local language	- Confusing to use/poor layout - Long text - Not enough or without illustration - Small size of fonts

Examples of the learning materials are provided in Table 9.

Table 9: Examples of sustainable design learning materials

Names	Descriptions
Information/Inspiration	The web-tool was developed for stakeholders in the design profession to gain better understanding of eco-design. It consists of two sections. The information section offers eco-design information related to designers. The inspiration section enables users to gain inspiration through existing eco-products (Lofthouse, 2001).
Design for Sustainability (D4S)	The D4S proposes to support SMEs to integrate sustainable design through providing step-by-step guidelines. The web-resource is also specific to developing economies and available in five languages including English, Spanish, Vietnamese, Lao, and Khmer (Crul and Diehl 2006).
Diselmex	The Diselmex web-tool was specifically developed for Mexican SMEs. It provides sustainable design information that the SMEs required, such as concept, evaluation tools, and certifications (Victoria-Uribe, 2008).

2.6.2 ESD learning and teaching strategies

Various teaching methods have been applied and introduced through a number of publications. This section presents leading strategies in two groups based on the

degree of participation: active learning strategies (2.6.2.1) and traditional learning methods (2.6.2.2). The section then emphasises the importance of lecturers in selecting classroom activities and constructing learning modules (2.6.2.3).

2.6.2.1 Active learning strategies

As discussed in Section 2.3.4, education reorientation is required to achieve learning and teaching of sustainable development. Various teaching strategies have been suggested. Table 10 summarises the strategies that have been employed in ESD learning.

Table 10: A list of pedagogic strategies related to active learning (Adapted form Cotton et al., 2009 and Segalas, 2009)

Active learning strategies	Descriptions
Project based learning	A set of experiences of learning that involves students in complex real world projects through which they develop and apply skills and knowledge.
Role-play	Role play can be defined as a learning process in which participants act the roles of other individuals to develop particular skills and to meet particular learning objectives.
Problem based learning	In problem-based learning a small group of students meets, with the support of a tutor, to analyse and to solve a problem designed to attain certain goals of learning.
Back-casting	Back-casting is the creation of a future vision, bearing in mind what is necessary to achieve in the future, and then working towards that goal from this day forward.
Fieldwork and outdoor learning	Research has shown that fieldwork is an example of experiential pedagogy that can influence students' emotions (Sivek, 2002) and help develop the critical thinking skills so essential to understanding the complexity of sustainability (Jones, 2003; Scott and Gough, 2003). Fieldwork for sustainability is often based on issues in the local community and environs, linking theory to real-world examples (Hope, 2009). There is also evidence that outdoor experience is an important precursor to understanding sustainability (Palmer and Suggate, 1996) and promotes learning by encouraging active learning (Hope, 2009).

Although the strategies have different characteristics and usages, they all encourage students to actively participate in the learning process. The term 'active learning' refers to a wide range of activities that have elements of *"involving students in doing things and thinking about the thing they are doing"* (Bonwell & Eison, 1991).

According to Tilbury (2011), active learning strategies have been promoted and applied in ESD learning as they encourages learners to:

- Ask critical reflective questions;
- clarify values;
- envision more positive futures;
- think systemically;
- respond through applied learning;
- explore the dialectic between tradition and innovation.

Active learning strategies provide learners opportunities to participate with others which lead to the higher retention rate than traditional teaching strategies (e.g. through lectures and reading) as illustrated in Figure 9.

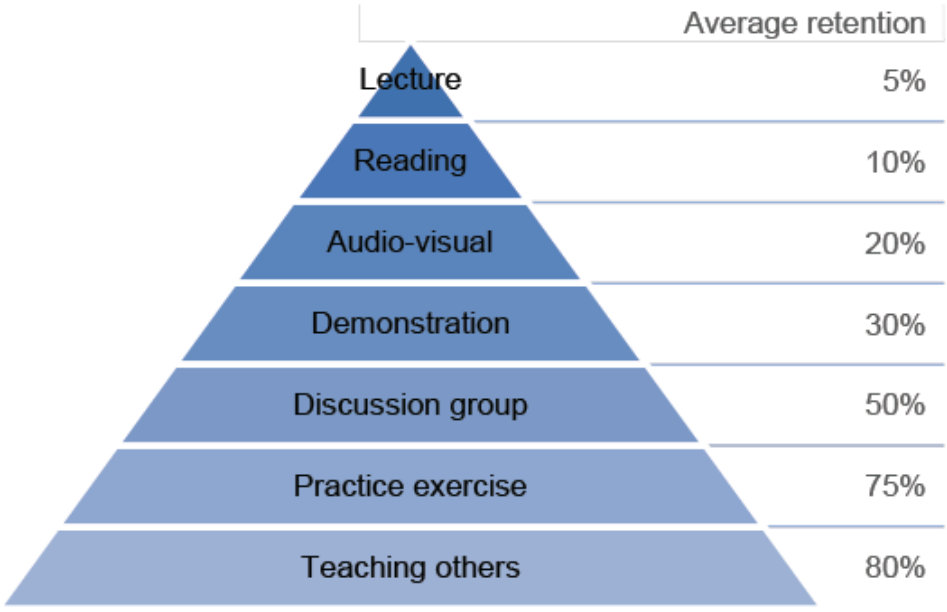


Figure 9: Bales' pyramid of learning average retention (Bales, 1996 cited in Segalàs, 2014)

More interactive activities lead to a better learning performance and higher retention rate. Dialogue and cooperation with others who have different backgrounds encourages intensified learning that influences the change in behaviour (Wals, 2010).

2.6.2.2 Lecture method

The lecture method is an oral presentation that is utilised to teach learners about particular topics; it can be employed to convey critical information, theories, history and equations (Medies, 2016). Remirez (2012) provides examples of lecture-based modules that are taught on industrial/product design courses. These are: design theory, design history, environmental science, ecology, society and culture, and sustainable development. He also states that the lecture-based class is traditionally constructed with activities that are led by lecturers. The lecture method is claimed to be ineffective and makes it difficult for students to achieve higher levels of cognitive and affective outcomes (Omelicheva and Avdeyeva, 2008); it is a one-way non-interactive method where students receive the message delivered by lecturers (Medies, 2016). This lack of interaction is one of its major limitations (Munson, 1992). As presented in Figure 9, the retention rate of the lecture method is lower than other strategies that involve student interaction. In addition, Hilas and Politis (2014) also imply that the lack of interactive activities leads to ineffective learning as it is difficult for lecturers to be aware of students' problems and their understanding of the topic without verbal feedback.

Although lecture-based classes do not comply with some requirements of ESD, the method is still widely utilised in HE due to the following benefits. Firstly, the lecture method is time and budget saving, and allows one lecturer to teach many students and is effective in transferring a large amount of information in a limited time (Omelicheva and Avdeyeva, 2008). It is appropriate to introduce new topics and summaries of what should be learnt (Sutherland, 1976). Secondly, it is simple and is one of the easiest ways for transferring knowledge to students (Kaur, 2011). It is also flexible and can be adapted to a wide range of topics and match with the need of particular audiences (Kaur, 2011; Omelicheva and Avdeyeva, 2008; Sutherland, 1976). In addition, it is appropriate to provide background knowledge and introduce new learning topics. In term of ESD, lecture based learning is appropriate for transferring basic principles of sustainability. It can be also used as a basis for other strategies and to encourage class interaction such as brainstorming, debates, and questioning (Medies, 2016).

As discussed in Section 2.3.4, most lecturers still rely on traditional lecture-based learning. Indeed, the method is partly utilised to teach topic related sustainable design in undergraduate product design courses in Australia (Remirez, 2012). However, many educators have acknowledged the need to use lectures in HE and attempted to develop the teaching methods to be more interactive and compatible with ESD. These approaches are shown in Table 11.

Table 11: Active learning activities for the lecture-based classroom (Adapted from Cotton and Winter, 2010; Segalàs, 2009)

Active learning strategies	Descriptions
Debate	Debates in which two groups of students put forward opposing arguments on an issue are often cited as a common method of teaching about sustainability since it encourages students to gather information about the topic and develop an argument. However, debates need to be carefully handled as they can become confrontational and learners may be discouraged from engaging or empathizing with others' views.
Group discussion	Group discussions are frequently mentioned by both school teachers and lecturers when asked to describe an appropriate pedagogy for sustainability. The use of discussion is an attempt to counteract the risk of the tutor taking a transmissive or authoritarian approach, thereby enabling students to explore their own and others' views. The facilitator often encourages listening and self-reflection rather than argument.
Case studies	This is another popular choice of pedagogy for teaching sustainability. Tutors describe using case studies to bring ESD into areas of the curriculum that had not traditionally involved a clear focus on sustainability, and to provide learners with a holistic view of an issue. Case studies enable students to investigate issues that affect their local area, to work with private enterprises and community groups and to work together in finding solutions for local issues.
Critical reading and writing	Reading and writing are seen by tutors as important social practices and the key to progressing sustainability and literacy. Learners can gain from deconstructing discourses to identify the possible motivation of the author. They may also be able to envisage alternative futures, and write a contrasting account based on differing perspectives.
Reflexive accounts	Considering their own position in relation to new knowledge about sustainability can help students understand how individual actions contribute to sustainability. This pedagogical approach provides opportunities for learners to reflect on personal roles, attitudes and responsibilities in relation to a range of sustainability issues.
Stimulus activities	A stimulus activity might involve watching a video or looking at photos, poems or newspaper extracts to initiate reflection or discussion. Students may even be involved in producing their own work such as photos taken to stimulate a discussion. Use of videos or externally produced documents has enabled facilitators to bring in a wide range of viewpoints for critical analysis.

2.6.2.3 Role of lecturers

As demonstrated through Section 2.6.2.1 and 2.6.2.2, both active learning strategies and lectures are useful for ESD learning though there is no one-size-fits-all approach for ESD as each group of learners has different requirements and backgrounds (Wals, 2009). This implies that previous work can only provide guidelines for starting ESD implementation. Along with their role as information providers, a lecturer is also expected to be a learning facilitator, student assessor, curriculum and course planner, and learning material creator (Crosby, 2000). Segalàs (2014) states that lecturers' beliefs and attitudes along with teaching strategies can directly affect students' learning experience and achievement of learning outcomes. This section then presents the previous works that show how lecturers select the strategies and construct ESD modules. Bonwell and Eison (1991) compare low-risk and high-risk applied active learning strategies in classrooms.

Table 12: Comparison of low-risk and high-risk active learning strategies (Bonwell and Eison, 1991; p.66)

Dimension	Low-risk Strategies	High-risk Strategies
Class time required	Relatively short	Relatively long
Degree of structure	More structured	Less structured
Degree of planning	Meticulously planned	Spontaneous
Students' prior knowledge of the subject matter	Relatively concrete	Relatively abstract
Students' prior knowledge of subject matter	Better informed	Less informed
Students' prior knowledge of teaching technique	Familiar	Unfamiliar
Instructors' prior experience of teaching technique	Considerable	Limited
Pattern of interaction	Between faculty & students	Among students

Table 12 shows that degree of risk is related to how the strategies are constructed; employing a loose-structure will lead to a higher rate of risk than a more fixed-structure (Bonwell and Eison, 1991). For example, using a short period of time and highly structured strategies (e.g. short writing activities and case studies) avoid

wasting class time and inadequate learning content. Boks and Diehl's (2006) work can be used as an example for the comparison between loose-structure and fixed-structure. They compare two sets of information that were collected from a sustainable design module called Design 5. The data was collected from several years of experience in integrating ESD into an undergraduate course. The study was carried out with final year students that were asked to work in groups of five and act as a design company. They were required to participate with clients that were selected from real-life companies. The business cases and/or design criteria were partly fictitious and modified from earlier years. Lecturers acted as coaches that facilitate and support learners in both cognitive and affective domains. The data was divided into two sets; the first set of findings was based on the data collected before the year 2003. The interpretation of this data was then utilised for the reorientation of the module. The second set of information was collected from the modified module. The data was compared as illustrated in Table 13.

Table 13: Comparison between two sustainable design modules that were summarised from Boks and Diehl (2006)

Class elements	Loose-structure (Until 2003)	Fixed-structure (after the modification)
Design criteria	Less emphasis on the goal related to sustainability *"The new product concept should target a 5% increase in turnover, and in a worst-case scenario result in a minimum net profit of 50,000 Euro. It should also be a good product from the sustainability perspective" (Boks and Diehl, 2006 p.936).*	More emphasis on the goal related to sustainability *"The new product concept should target a 5% increase in turnover, and in a worst-case scenario result in a minimum net profit of 50,000 Euro. It should be analysed in what way sustainable innovations could contribute to these goals, and whenever opportunities to do so are present, priority should be given to such innovations" (Boks and Diehl, 2006; p.936).*
Client	Most of the representatives had little experience in sustainable design implementation and did not stress sustainability issues.	The representatives had been trained and asked to give more focus on sustainability.
Coach	Two sustainability specialists were provided to consult students on topics related to sustainability during the module. However, they could not fully concentrate on the consultant as their major roles were as coaches.	The major role of the two specialists was as sustainability consultants. They were then able to provide full support to issues related to sustainable design.

As presented in Table 13, the structure in 2003 is more related to a high-risk strategy as the module was less structured. The later version is considered as a low-risk strategy as it took more control; most of the class elements were required to emphasise and support sustainability. Eison (2010) found that a highly-structured strategy avoids the risk of inadequate learning content. Boks and Diehl (2006) conclude that the more fixed strategy is more productive in learning and teaching sustainability and found that students were distracted from the business reality that gives more focus on generating profit.

Another predominant topic that has been widely discussed is about the appropriate learning strategies for ESD: active learning and/or lecture based learning (Levintova and Mueller, 2015). As discussed in Section 2.6.2.1, lecturers have been encouraged

to shift from a lecture method to a more active learning approach that enables students to reach a higher retention rate. However, Section 2.6.2.2 shows the need to adopt a lecture method due to its advantages. Local relevance is required to achieve the implementation of ESD and each teaching strategy has different strengths and weaknesses; and compatibility with different class conditions. Lecturers play a crucial role in matching learning strategies that are appropriate to the requirements of the class and students. Walberg and Paik (2000) recommend that the use of a variety strategies will be more productive than solely the use of active learning. Levintova and Mueller (2015) also support the use of mixed strategies and present the successful examples. They originally employed a role-play (active learning) strategy to teach sustainability due to the influence from the Global summit. They found that students struggled to understand the TBL due to a lack of substantive instruction. The module was then adjusted; additional lecture classes were included alongside active learning. They report that 9 out of 12 students (75%) were able to gain an insight into TBL and another 25% could understand at least two sustainability pillars.

2.7 Sustainble development in South-East Asia

This section presents the current status of sustainable development in South East Asia, a sub-region of the Asia Pacific region. It discusses specific sustainability issues that all state members have in common. The section starts by introducing Association of Southeast Asian Nations (ASEAN) and its role (2.6.1). It then reveals the existing activities related to the implementation of sustainable development (2.6.2) and EE (2.6.3).

Figure 10: Southeast Asia Map

2.7.1 Association of Southeast Asian Nations (ASEAN)

In 1967, ASEAN was initially established by the five founding members: Indonesia, Malaysia, Philippines, Singapore and Thailand. It currently consists of 10 member states including: Brunei Darussalam, Cambodia, Lao PDR, Myanmar, and Viet Nam. It mainly aims to accelerate economic growth, social progress, and cultural development among the ASEAN member countries (AMCs) (ASEAN, n.d.). To achieve these aims, three communities have been established based on the areas that the state members need to be developed; they are Political-Security Community (PSC), ASEAN Economic Community (AEC), and ASEAN Socio-Cultural Community (ASCC) as seen in Figure 11 (Keng, 2009).

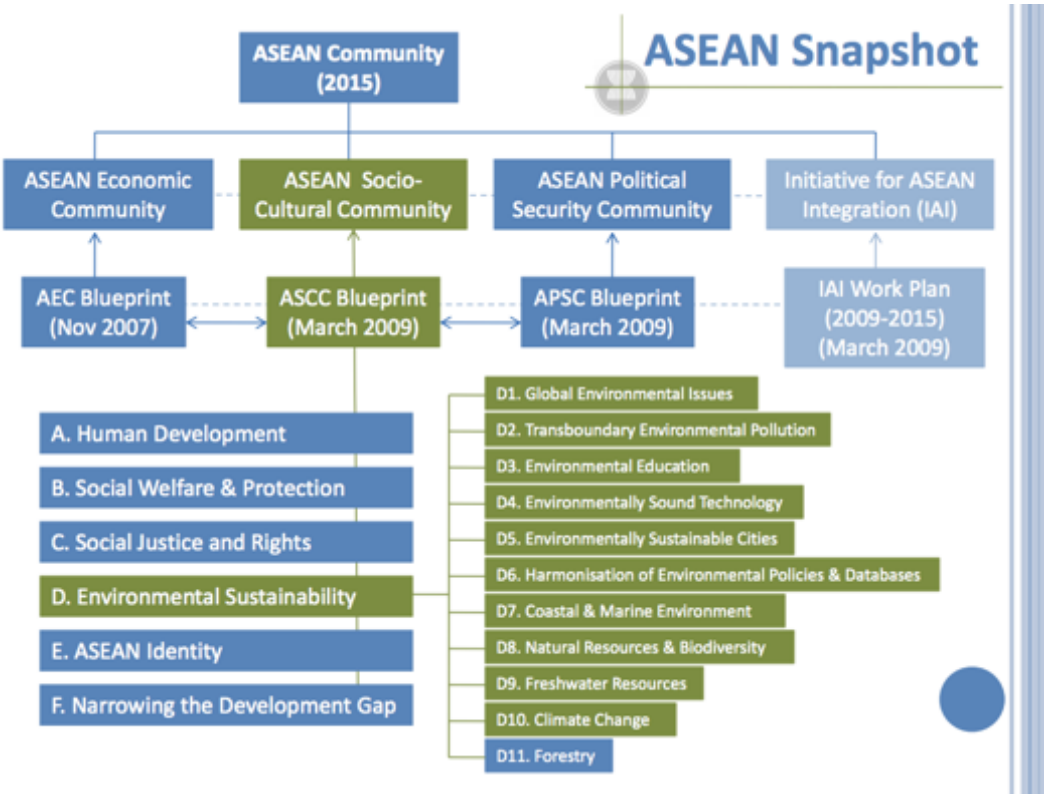


Figure 11: Environmental Cooperation in the Roadmap for an ASEAN Community 2009 – 2015 (ASEAN, 2009)

Each sub-community is responsible to provide a detailed strategic plan to enable the members to take actions and achieve countries' development. According to its blueprint for 2009-2015, the ASCC is in charge of contributing to sustainable development and intends to address sustainable issues in six areas under the following headings: (A) Human Development; (B) Social Welfare and Protection; (C) Social Justice and Rights; (D) Ensuring Environmental Sustainability (E) Building the ASEAN Identity; and (F) Narrowing the Development Gap. This thesis is focused on investigating the existing policies and initiatives that facilitate the implementation of sustainable development.

2.7.2 Regional actions on Sustainable Development

Although ASEAN has launched ASCC policies to facilitate sustainable development, it has not enacted the law to force the member states to follow the policies, although the regional community has since been required to encourage all members to actively provide cooperation to the region and implement the policies in their own countries (ESCAP, 2003). Different activities including medium-term action plans, declarations, and sustainable development initiatives have been developed and applied for calling for action. Some recent activities are shown in Table 14.

Table 14: ASEAN's activities that are related to sustainable development (ASEAN, 2009a)

ASEAN Facts and Figures	
Policy Framework for Sustainable Development Cooperation in ASEAN	• ASEAN Vision 2020 (15 December 1997) • ASEAN Concord II (7 October 2003) • ASEAN Charter (15 December 2008) • Roadmap for an ASEAN Community (1 March 2009)
Strategic Objectives and Actions on the Environment	• Section D: Promoting Environmental Sustainability of the ASEAN Socio-Cultural Community Blueprint (2009 – 2015)
Most Recent Declarations/ Agreements related to the Environment	• The Cebu Resolution on Sustainable Development (2006) (ASEAN Environment Ministers) • The ASEAN Declaration on Environmental Sustainability (2007) (ASEAN Summit) • The ASEAN Declaration on the 13th Session of the Conference of the Parties to the UNFCCC and the 3rd Session of the CMP to the Kyoto Protocol (2007) (ASEAN Summit) • The Singapore Declaration on Climate Change, Energy and the Environment (2007) (EAS Summit) • The Cha-Am Hua Hin Declaration on the Roadmap for the ASEAN Community (2009 – 2015) (ASEAN Summit) • Joint Statement to the 15th Meeting of the Conference of Parties to the UN Framework Convention on Climate Change and the 5th Meeting of the Parties to the Kyoto Protocol (2009) (ASEAN Summit) • Singapore Resolution on Environmental Sustainability and Climate Change (2009) (ASEAN Environment Ministers)

The vulnerability to the negative impacts of climate change is a major concern to ASEAN. The community has carried out a number of environment related initiatives since 1977. ASEAN cooperation on the environment started with the assistance of UNPE, which carried out a study to identify the gap in the environmental field and propose recommendations to address the problems. The ASEAN Experts Group on the Environment (AEGE) was established to facilitate environmental cooperation in the region and adopt the UNPE suggestions. In 1989, the AEGE was changed to the ASEAN Senior Officials on the Environment (ASOEN) to enhance the capability and responsibility for the issues. The committees of this ASEAN bureau comprise heads of environmental departments/ministries who are obviously responsible for environmental issues at the state level (ASEAN, 2009a). They are required to attend the annual meeting which aims to propose the direction for implementing and monitoring regional initiatives (ASEAN, 2009a).

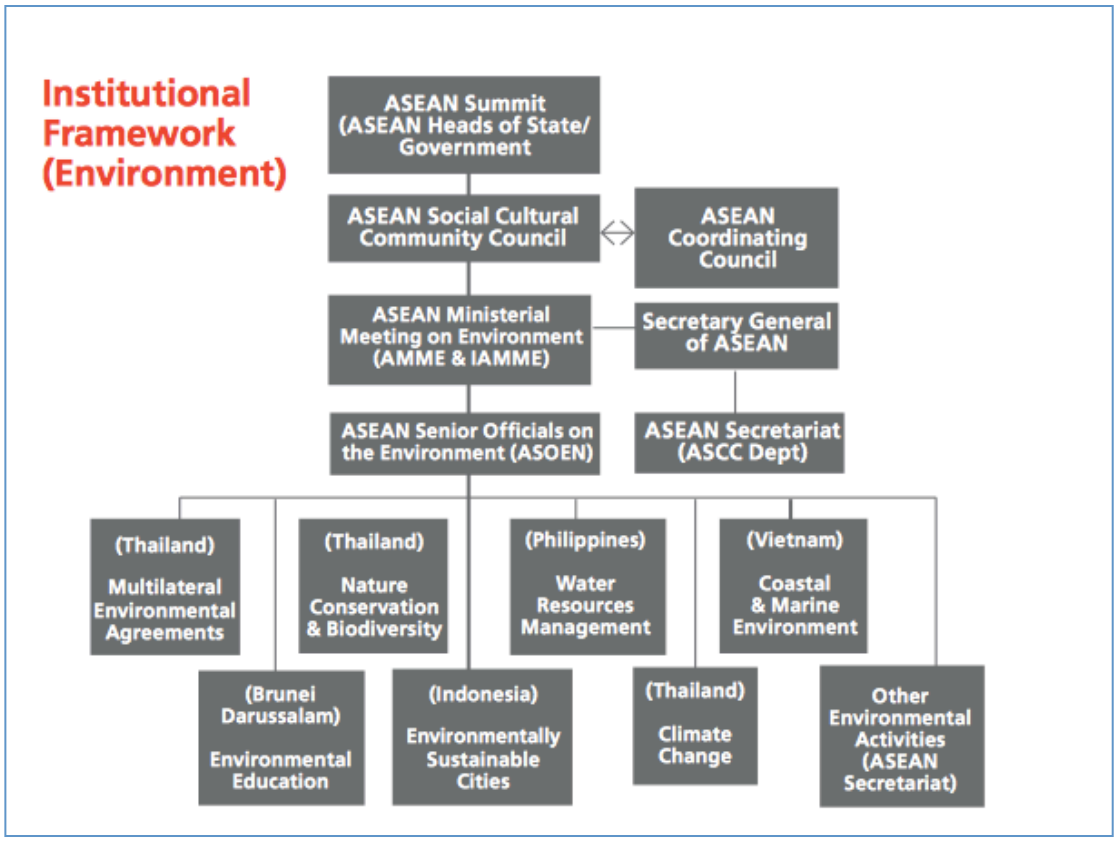


Figure 12: ASEAN Institutional Framework for Environmental Cooperation (Letchumanan, 2010)

Seven subsidiary bodies have been established to support the environmental bureau as seen in Figure 12. They initially had only six working groups:

- ASEAN Working Group on Coastal and Marine Environment (AWGCME)
- ASEAN Working Group on Environmental Education (AWGEE)
- ASEAN Working Group on Environmentally Sustainable Cities (AWGESC)
- ASEAN Working Group on Multilateral Environmental Agreements (AWGMEA)
- ASEAN Working Group on Nature Conservation and Biodiversity (AWGNCB)
- ASEAN Working Group on Water Resources Management (AWGWRM)

In response to Agenda 21, ASOEN came up with 10 strategies for the member states and carried out 27 environmental initiatives in 1994 through the six subsidiary bodies (Kato and Takahashi, 2000). The ASEAN Working Group on Climate Change (AWGCC) was added in 2009 to support the implementation of climate change activities that propose in ACC blueprint (ASEAN+, date). The ASEAN Secretariat supports these seven working group through providing resources, advices and information (Letchumanan, 2010).

2.7.3 Envronmental Education in ASEAN

As discussed in Section 2.3, education is an essential element to achieve sustainable development. ASEAN is also aware of this and has launched a great number of education initiatives to support sustainability. The regional community currently gives the priority to the integration of EE as reflected in the ASCC blueprint shown in Figure 12. AWGEE then adopted the first ASEAN EE action plan (AEEAP). It is considered as a mid-term action plan that provides guidelines to the member states for implementing EE at both national and regional levels. The first AEEAP 2000-2005 proposed to satisfy four targets: formal education, non-formal education, capacity building, and networking and partnerships (Letchumanan, 2010). After the first action plan ended, the development of a successor plan was then called for and encouraged through DESD. Consequently, the AEEAP 2008-2012 was adopted and considered as ASEAN's contribution to the implementation of ESD at the international level, particularly in the Asia-Pacific area (ASEAN+, 2010). As the

successful result of the previous action plan, the AEEAP 2014-1018 has been published. The current action plan emphasises on transformative learning approaches that focus on the three learning domains as reflected in its main objective: *"…to realise a clean and green ASEAN with citizens who are environmentally literate, imbued with environmental ethics, willing and capable to ensure the sustainable development of the region…"* (ASEAN, 2013; p.3).

The AEEAP action plans (ASEAN, 2007; ASEAN, 2013) have encouraged a great number of EE initiatives, however the review of white papers and publications related to EE implementation in ASEAN member states indicates that the initiatives launched before 2013 did not dedicate their focus to HE, as seen in Table 15.

Table 15: A list of initiatives related to Environmental Education (ASEAN, 2009)

The name of initiatives	Descriptions
ASEAN green school:	To establish ASEAN Green/ Sustainable/ Eco-school Network, to promote sustainable schools
ASEAN leadership programme:	To conduct an ASEAN EE for sustainable development leadership training programme for key target groups
ASEAN Environmental Education Inventory Database (AEEID):	To strengthen the network of ASEAN member states and partner organisations for information dissemination, exchange and learning for EE and ESD in ASEAN
ASEAN Youth Portal on Sustainable Development:	To initiate youth action for sustainable development programme, to develop an ASEAN-wide Youth for a sustainable environment network
ASEAN ESD film festival:	To initiate a competition-based ASEAN ESD film festival, to build and strengthen existing networks of NGOs, universities and media throughout the region to be effective practitioners, promoters, communicators and agents of change for EE and ESD

In summary, ASEAN has provided a significant contribution to sustainable development through encouraging and facilitating the member states to implement policies relating to sustainability. The regional community emphasises the role of the education sector and has established AWGEE to directly support educational initiatives. However, most of the initiatives only focus on the environmental pillar and neglect the social pillar. This is because climate change is the top priority of ASEAN as the members are at high risk of disasters that are caused by climate change. Environmental problems are more common to member states as they are in the same area, while there are varied social issues owing to the diversity of population in terms of culture, nationality, and religion.

2.8 Thai context

The implementation of sustainable development and ESD seems to be on the world's agenda but as previously mentioned, there is 'no one size fits all' approach (Tilbury et al., 2007). Each country has different problems and sustainability priorities based on its context, such as local history, culture, and politics (Wals, 2009). UNESCO (2012) underlines that ESD implementation should be locally relevant and culturally appropriate; ESD is expected to address the local environment, social and economic contexts. In addition, Hopkins and McKeown, (2005) suggest that understanding on the current state of ESD is necessary to ESD implementation; decision makers are required to investigate existing initiatives that have been carried out in both formal and informal education.

Consequently, a literature review was employed to acquire information regarding the Thai context that was utilised to develop the learning framework. This section reveals the current state of sustainable design in Thailand by categorising it into three subsections: an overview of sustainable development in Thailand (2.8.1), the implementation of ESD in Thailand (2.8.2), and the online network of eco-design in Thailand (2.8.3).

2.8.1 Overview of sustainable development in Thailand

According to the 8th National Economic and Social Development Plan (1997-2001), the Thai economy has experienced significant growth over the past three decades; the average income per person increased from 2100 THB (≈ 40.40 GPB) in 1961 to 68000 THB (≈1308.42 GBP) in 1994. Although Thailand has achieved economic growth, it has faced social and environmental problems caused by unsustainable development (OPM, 1997). Urban and rural income inequity has contributed to increased migration to urban areas resulting in negative societal impacts, such as overcrowding, unemployment, and crime (Prayukvong, 2005). Natural wealth has been over consumed; more than 790,000 acres of forest was lost between 1992 and 1993. This deforestation has contributed to soil erosion and deterioration of water quality (OPM, 1997). Furthermore, the rapid economic growth led the country to face a severe financial crisis in 1997. The Thai industry has shifted its approach from an agricultural based economy to an industrial based economy and accumulated policies that support financial liberalisation. The government has launched policies that facilitate financial institutions to acquire capital investment from overseas and increased the cash inflow for Thai industry. But, most of the foreign debts were invested in the businesses that do not contribute to the national income and caused a balance of trade deficit (Feldstein, 1999; Corsetti, 1998). At the same time, the Thai currency was pegged to the US dollar and resulted in its over-valuation that obstructed the export industry from competing in the international market, and allowed end-users to consume imported products. To support the Thai economy, the government was forced to float the Thai baht that was devalued from 25 Baht per US dollars to over 50 Baht per US dollar in 7 months (Feldstein, 1999). Many financial institutions and companies were affected by the decreasing values of the Thai currency as they had acquired foreign debts. Some companies went bankrupt or had to lay off their employees. The official unemployment rate increased from 1.4% in 1997 to 5.1% in 1999 (Lane, et al. 1999). These circumstances drove the government to give more focus to sustainable development; a great number of governmental agencies have been established to provide support including funding, marketing, and product development. In other words, economic benefits could be considered as key drivers that encouraged the Thai government to carry out initiatives related to

sustainable product development. All the existing initiatives are intended to help participants to achieve the business challenges as illustrated in the following sub-sections. The initiatives can be classified into three groups based on their predominant focuses: eco-design (2.8.1.1), One Tumbon One product (OTOP) (2.8.1.2), and sufficiency economy (2.8.1.3)

2.8.1.1 Eco-design (Environmental sustainability)

Since 1990, environmental impacts have increasingly been considered in Thailand's manufacturing industry and the country has started to build the infrastructure needed to support Thai SMEs in complying with the requirements of the international market relating to environmental issues (Lindahl, 2008). Mungcharoen, Yuvaniyama, Chomkumsri & Varabuntoonvit (2006) present an overview of the eco-design movement in Thailand:

Table 16: Eco-design concepts in Thailand (adapted from Mungcharoen, et al. 2006)

Year	Organisations	Descriptions
1990	FTI/DIW/TEI	Cleaner Technology in Thai industry
1996		Cleaner Technology Concept to Education
1997		Promote a concept of life cycle assessment (LCA)
1999		Introduce eco-design concept
2001	KU/AIT	Establish Thai LCA network / Teaching LCA at AIT, LCA and Eco-design at KU
2002-2007	MTEC	Knowledge Transfer from Japan and Promote Eco-design Concept
2005		LCA/Eco-design in EE Sectors
2006	MTEC	Thai Green Design Network (TGDN)

As seen in Table 16, eco-design was initially introduced in the Thai manufacturing industry in 1999 by government and non-government organisations (Mungcharoen, Phanichavalit, Yuvaniyama & Chomkhamsri, 2007). Eco-design has been given greater consideration because it enables the export industry to comply with the requirements of the international market (Mungcharoen, et al. 2006). Hence,

government agencies were specifically established to support Thai manufacturers' development of eco-products. The National Metal and Materials Technology Centre' (MTEC) is acknowledged as one of the main organisations that are playing an important role in implementing eco-design in Thailand (ASEAN+, 2010). MTEC aims to support research related to materials development and provide a significant contribution to industry by providing knowledge. The agency has set up an environmental research unit comprised of the following five departments: Life Cycle Assessment Lab, Excellent Centre for Eco-Products (XCEP), Environmental Management Lab, Material for Hazardous Substance Free Product lab, and Material for Environmental Lab. These departments have cooperated with other organisations including universities and non-government agencies to launch eco-design initiatives (MTEC, 2008).

Human resource development activities, including workshops and seminars have been carried out to introduce eco-design principles to industry (Mungcharoen, et al. 2007). Since 2008, XCEP has organised an annual competition that allows all Thai residents, including students, SMEs and designers, to participate (MTEC, 2008). Selected candidates are invited to attend an eco-design camp which provides instruction on the basic principles and enables the participant to develop their own products. Moreover, it has contributed to the launch of a set of e-learning courses that offer eco-design knowledge through the www.learn.in.th website (MTEC, 2008).

MTEC also conducts research to facilitate eco-product development. For example, it has developed software called 'Thai GHGs+ Software' that enables manufacturers to estimate amounts of greenhouse gases resulting from production processes (NSTDA, 2011). A consultancy service is also provided to help manufacturers to implement eco-design. Thirdly, MTEC have established a series of eco-design networks. Lindahl (2008) believes that online networks are appropriate resources for eco-design because they allow Thai SMEs to access information on product development. The Thai Green Design Network (TGDN) was officially introduced in 2006; it proposes to transfer knowledge and technology on eco-products and create online network to promote the concept (Mungcharoen, 2007). MTEC also provided funding to establish the ThaiRoHS website which assists electrical and electronic manufacturers in

complying with international standards by providing information (ThaiRoHS, 2006). The findings indicated that end-users in Thailand lack understanding of eco-design and MTEC is attempting to overcome this barrier by helping green manufacturers to increase sales through educating Thai consumers. For example, the eco-product directory was initially published as a printed catalogue that displays product images and descriptions. In 2013, the directory had over 6000 eco-products and was made available as an online catalogue (Mungcharoen, 2013).

2.8.1.2 One Tumbon One Product (OTOP) (Social sustainability)

Thailand has implemented initiatives to create well-being and contribute to rural development to reduce inequity of income and facilitate local entrepreneurship (Natsuda, et al, 2012). In 2001, the Thai government adapted a Japanese policy entitled, 'One-Village-One-Product' (OVOP), a successful model of a regional programme to promote rural development. The OVOP allowed rural communities in Japan to gain opportunities for economic growth by developing and enhancing local businesses. Each village was encouraged to create a regionally distinctive product using local resources that complied with the requirements of the international market (Natsuda, et al, 2012). This programme has successfully stimulated economic development in rural areas and resolved social problems, such as overcrowding in cities, low standards of living in rural areas, and environmental issues (Igusa, 2006). Local government structure in Thailand can be divided into 4 levels: 76 provinces, 876 districts, 7255 sub-district (Tambon in Thai), and 79830 villages (Aukkaravittayapun, 2004). The OVOP programme, renamed 'One-Tambon-One-Product' (OTOP), was first applied at the sub-district levels of Thailand in 2001. It was initially introduced to SMCEs but later included SMEs. The original scheme operated on a local level (from the bottom up) but the Thai central government plays a major role in running the OTOP programme (from the top down) and provides various types of support. As shown in Table 17, the focus of the OTOP programme has been modified every year since its inception (Natsuda, et al. 2012).

Table 17: OTOP focus activities from 2001-2010 (Natsuda, et al. 2012)

Year	Activities
2001	Ministerial Integration
2002	Search for OTOP Products
2003	OTOP Product Champion
2004	Standard Champion
2005	Marketing OTOP
2006	Search for Excellent OTOP and OTOP Village Champion (OPC)
2007	Knowledge-Based OTOP
2008	Entrepreneur Promotion
2009	OTOP Tourism Village
2010	Sustainability of OTOP

As seen in Table 17, although OTOP aims to contribute to rural development in terms of both economic support and human resources, most of the OTOP directions have predominantly focused on economic issues. For example, the OTOP Product Champion (OPC) scheme has been introduced to enhance the export capability of the OTOP participants (Natsuda, et al. 2012). The scheme aims to help the rural producers to create brand awareness of the local products by advertising them through use of the OTOP logo. OTOP producers are invited to submit their distinctive products which are then graded and awarded stars-certificates according to: exportability and brand quality, sustainability of and consistent quality of production, customer satisfaction, and impressive background story (Kurokawa, et al., 2010). Four and five star certificates are granted to OTOP products which are of high quality and have export potential (Kurokawa, et al. 2010). Producers achieving three stars and above are eligible to access government funding and trade their products in the OTOP Expo, an annual trade fair in Bangkok. In addition, the local government provides some financial support to rural entrepreneurs (Natsuda, et al. 2012).

2.8.1.3 Sufficiency economy (Economy sustainability)

In 1997, the country faced the harsh financial crisis owing to the rapid but unsustainable growth in the Thai economy. The economic collapse resulted in a large foreign debt as discussed in Section 2.8.1. Sufficiency economy philosophy (SEP), first introduced in 1974, was then reintroduced to recover the Thai economy; it provides a way of development that is more resilient, sustainable, and better able to conquer the challenges emerging from unpredictable changes (National Economic and Social Development Board, n.d.). The philosophy was developed based on the Thai context and bestowed by HM King Bhumiphol, the king of Thailand (ORDPB, 2004; Piboolsravut, 2004; Fusakul, 2010). The concept was firstly introduced during the royal speech at Kasetsart University:

> *Economic development must be done step by step. It should begin with the strengthening of our economic foundation, by assuring that the majority of our population has enough to live on. ... Once reasonable progress has been achieved, we should then embark on the next steps, by pursuing more advanced levels of economic development. Here, if one focuses only on rapid economic expansion without making sure that such [a] plan is appropriate for our people and the condition of our country, it will inevitably result in various imbalances and eventually end up as failure or crisis as found in other countries. (cited in Fusakul, 2010)*

The King's philosophy provides a different view of economic development that encourages the moderation of aspiration, and balance between success and fulfilment (Chalapati, 2008). The philosophy utilises the Buddhist concept of the *"middle path"* to encourage Thai citizens to live sustainably and be able to withstand the challenges from globalisation and other situations (Bunyasrie, 2010). The philosophy can be applied at all levels: individual, families, communities, and nation. It can be elaborated through its three components that are interlocked and independent as shown in Figure 13.

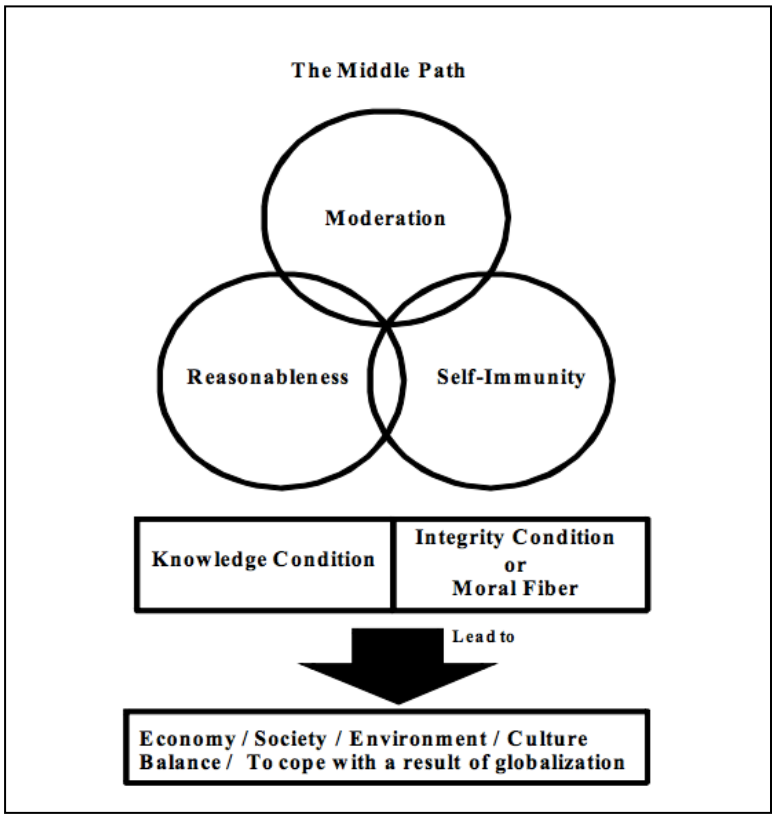


Figure 13: Sufficiency economy framework (Wibulswasdi et al. 2011)

Firstly, the *"moderation element"* is considered as the core concept of SEP. it gives an idea to *"live in the middle path"* which is the way to balance livelihood; not to be extravagant and to be thrifty (Naipinit et al., 2014). In other words, SEP encourages individuals to live based on need rather than want (Bocken and Short, 2016). The second element is *"reasonableness"*, which means evaluating the reasons for any actions that leads to understanding of all causes and effects (Siridej and Fusakul, 2010). Lastly, the *"self-immunity element"* implies self-protection from negative impacts that can be raised from internal and external changes. In other words, it is an ability to resist shocks and adapt to external changes that cannot be predicted and controlled (Baker, 2007).

Apart from the three main elements, two conditions are required to fulfil the implementation of SEP. "Knowledge" is needed to enable the users to accumulate information, have an insight into it, and prudently apply the information. Another condition called *"morality",* refers to ethical behaviour, honesty, perseverance, and not exploiting others (Siridej and Fusakul, 2010; Mongsawad, 2010).

2.8.2 Education for sustainable development in Thailand

Although ESD requires the consideration of TBL, the educational philosophy in Thailand appears to be a factor undermining the holistic approach towards sustainability. Having said that, sustainability in the context of Thai education is often segregated into three elements: social sustainability, EE and sufficiency economy but has failed to balance the three pillars together. As a result, the Thai manufacturing community has a tendency to consider one or two particular pillars (see Section 2.7). The findings from the literature review indicate that the Thai education sector has given most focus to eco-design and/or EE due to the influence of business and ASEAN. Integrating eco-design into the Thai industry is a benefit to the national economy as it enables companies to comply with the environmental requirements of the international market (Mungcharoen, 2007). Thailand (as one of the ASEAN members) has been encouraged to promote and implement EE since 1978 (Sunchindah, 1998). Although the country has a strong tradition of EE, most related publications and initiatives are only available in a few disciplines, such as environmental science and engineering. It is because these two are directly related to the concept of eco-design and allow lecturers to easily link the concept to their subject areas (Dawn et al., 2005; McKeown and Hopkins, 2006). As discussed in Section 2.7.1.1, the National Science and Technology Development Agency (NSTDA) and its affiliations are responsible to facilitate the implementation of eco-design. They have also contributed to the implementation of EE through carrying out some initiatives that target undergraduate students:

- Learn online: web based information that allows learners including undergraduates, master students, PhD researchers, academic staff, and the public to attend virtual education. NATDA and XCEP have cooperated to develop and launch short courses related to sustainable design as shown in Table 18. The course descriptions show that most of the courses related to sustainability were developed based on engineering disciplines as reflected from their course outlines and background of lecturers.

Table 18: Sustainable design short-courses that are provided by the Learn online project (Learn, 2012).

Subjects	Thai Baht	Pound Sterling
Life cycle assessment	3000	60
Introduction to sustainable product design	2500	50
Eco-design fundamental	2500	50
Application of eco-design	2500	50
Clean technology	2500	50
Resource recovery and recycling	2500	50

- Eco-design contest: XECP encourages Thai residents to practice eco-design through organising this eco-design contest. It is categorised into three groups which are secondary school, HE, and professional levels. All applicants are asked to submit their sketch ideas that include perspective views and details. The selected candidates are required to attend eco-design workshops, which facilitate them to develop their design and then resubmit them. Examples of the winning product at the undergraduate level is a *Plantcil* sharpener. It utilises the waste from sharping pencils to grow a plant as shown in Figure 14.

Figure 14 Winning product of eco-design contest 2009 (NSTDA, 2009)

Although a great number of initiatives have been carried out to support integrating EE into the Thai education system, the literature review indicates the lack of eco-

design modules in Thai undergraduate degrees. Lindahl (2008) investigated the status of eco-design in Asia by focusing on electronic engineering. He found that most of his participants who were working on eco-product development had acquired their environmental literacy from different sources, such as international training, eco-design workshops and seminars. However, none of them had obtained the eco-design knowledge from their courses in universities. Moreover, Tikul and Srichandr (2007) also show the lack of eco-design courses in the architectural field. Despite postgraduate and undergraduate degrees in architecture being offered in 26 institutions across the country, there are no undergraduate courses that are specific to eco-design. According to the review of product design course curricula, many Thai HEIs locate product design course within the faculty of architecture.

2.8.3 Online network of eco-design in Thailand

Lindahl (2008) believes that online networks are appropriate resources for Eco-design because they allow Thai SMEs to access information on product development. Lofthouse (2006) also agrees that a web-based format is appropriate to provide design information because it can satisfy the requirements of knowledge transfer: (i) providing highly visual and interactive media, (ii) offering a large amount of information in a minimum amount of text, (iii) enabling users to have convenient access, and (iv) ease of update. Moreover, research by Sirinaruemitr (2004) found that the Ministry of Information and Technology (MICT) has attempted to support online communication, through decreasing the price of personal computers and providing more internet access in Thailand. This section discusses eco-design networks that are available to support the Thai manufacturing industry. Five networks are selected because they are directly related to design for the environment.

Mungcharoen[3] (2006) describes four eco-design networks that were established between 1999 and 2006 as shown in Table 19. Additionally, the eco-product

[3] Mungcharoen is one of the key authors of Eco design in Thailand; he is a director of the Cleaner Technology Eco-design Research Unit of Kasetsart University and an expert in eco-product development of MTEC (KU, 2013).

directory is considered because it provides specific information about eco-material and was created by MTEC, the main organisation that supports and promotes eco-design in Thailand.

Table 19: List of Thai eco-design networks

Year	Networks	Descriptions
1999	Thai network for eco-efficiency and cleaner production http://tnec.info	Provides information in eco-efficiency and cleaner production. It also enables members to request information through posting questions on a web-board feature.
2001	Thai LCA network http://doi.eng.cmu.ac.th/Thailca/	Provides knowledge about using life cycle assessment and resources. Members are allowed to communicate with each other through a web-board.
2005	Thai RoHS forum www.thairohs.org	Aims to facilitate eco-product development within the electronics industry by enabling manufacturers to exchange production knowledge.
2006	Thai green design network (TGDN) www2.mtec.or.th/website/index.aspx	Aims to (i) transfer knowledge of design for environment and (ii) promote eco-design activities. Target users of this network are academic staff, designers, and members of private and government organisations in the Thai product industry (Mungcharoen and Yuvaniyama, 2006).
2010	Eco-product directory http://thaiecoproduct.mtec.or.th	A directory of eco-materials and eco-products; which aims to create a business network and distribution channel.

As shown in Table 19, some networks are available but they are not specific to industrial designers. Thus, the designers may not be able to utilise them because the information is not presented in an appropriate format. However, according to Mungcharoen and Yuvaniyama, (2006) the TGDN considers designers as one of the main users. Thus, the study focuses on this network; it is discussed by comparing it to the desirable characteristics of online tools discussed in Section 2.6.1.

According to Section 2.6.1, the TGDN may not be suitable for designers because it lacks desirable characteristics that enable users to gain an understanding of sustainable design. Firstly, information is mainly presented in a text format but

designers prefer to consume information through media that has a high quality of graphic use and less text (Victoria-Uribe, 2008; Lofthouse; 2006). Secondly, few examples of design case studies are provided. Victoria-Uribe (2008) believes that offering design case studies is one of the most important functions in the information provision tool; examples of products enable designers to generate new ideas (Bhamra and Lofthouse, 2003).

2.9 Conclusion

The issue of sustainability is largely influenced by product designers as they can influence manufacturers in the selection of processes and materials (Bhamra, 2007). HEIs have been recognised as key agents of change that play a crucial role in the fundamental step of implementing sustainability (Buckler and Creech, 2014; Barth, 2007; McKeown, 2002). This is because HE equips future decision makers (product designers) with knowledge and skills required for sustainable development (Cortese, 2003 cited in Johnston, 2007).

However, Section 2.3.4 highlighted that the traditional education system is not able to satisfy the major aim of ESD, which is to provide learners with knowledge, skills and values required to encourage a deep change in behaviour and live sustainably. UNESCO and other key authors underline the need to reorient the education system. As discussed in Section 2.3.4.1, transformative learning is considered as a more appropriate way to learn sustainability as it expands the scope of traditional methods that only engage learners through cognitive (head) and psychomotor (hands) domains. The new approach also includes the affective (heart) domain that is associated with learners' attitudes and values. As discussed in Section 2.3.3, integrating values inherent to sustainable development is required to achieve ESD and societal transformation. UNESCO emphasises that values and attitudes are directly related to how humankind behaves towards others. Section 2.6.2 provides a list of teaching strategies (e.g. problem-based learning, service-learning, and role play) that can be utilised to engage learners though the three learning domains.

In addition, Section 2.3.4.3 underlines that educators are required to change their focus from content preparation (input) to learning outcomes (output) due to the

complex nature of ESD. It seems impossible to prepare sets of content that cover all sustainability challenges and enable learners to solve problems.

Section 2.4 introduces sets of competencies (output) that are required to achieve sustainable development. The work of Wiek et al. (2011) is predominant as it presents the set of competencies in a problem-solving format and shows their relationships through intervention processes of sustainable development (presented in Figure 6). The five competencies are system thinking, anticipatory, normative, interpersonal, and strategic competences. Along with these five competencies, critical thinking is also included as it enables learners to have an insight into the current issues and understand how existing actions were employed (discussed in Section 2.4.6).

As demonstrated through discussions, ESD has been widely acknowledged and implemented. However, UNESCO found that many have failed to implement ESD due to two main obstacles. Firstly, Section 2.5 presents common barriers that are originated from the shortage of lecturers with capability in sustainable development. Lecturers are required to have an insight into the principles of sustainability and be aware of appropriate strategies for its delivery because they play an important role in the development of courses and/or modules that aim to enable learners to acquire the competencies required. The second reason is a lack of local relevance. Some governments have adopted curricula from others but successful ESD implementation should address local environmental, social and economic issues (UNESCO, 2012). Tilbury et al. (2007) noted that a one-size-fits-all approach for ESD is not appropriate due to the significant difference in contexts (e.g. geographical and cultural contexts).

Consequently, Section 2.7 and 2.8 initially investigated the Thai context by starting with an overview of sustainable development and ESD implementation in Thailand and South-East Asia. Section 2.8 found that the implementation of both the above have been influenced by economic drivers. This was reflected through the existing initiatives that are illustrated in Section 2.8.1. These were classified into three groups based on their predominant pillars: (1) eco-product development (environmental

concern), (2) OTOP (social concern), and (3) sufficiency economy (economic concern). Although social and environmental aspects were considered, the main priority of the initiative is to enable participants to conquer economic challenges. Firstly, Section 2.8.1.1 showed that the Thai manufacturing industry has quite a strong background in eco-product development, which allows it to comply with the requirements of the international markets. Secondly, since the economic crisis in 1997, the Thai government has promoted OTOP and sufficiency economy to recover the national economy. Section 2.8.1.2 presents that OTOP was employed to stimulate economic development in rural areas. Section 2.8.2.3 reveals that the concept of sufficiency economy was used to encourage individuals and companies to securely develop their infrastructure and avoid economic risk. A similar situation also happened in the education sector as presented in Section 2.8.2, Thai HEIs give most focus to EE due to the influence from business and ASEAN.

This PhD research proposes to address the two obstacles (lack of lecturers with capability in sustainable development and local relevance) through the development of a new material/solutions that support Thai lecturers in implementing ESD. The Thai context was utilised to identify the requirements of material/solution development. The first assumption was developed from the findings that are presented in Section 2.8, which reveal that Thailand mainly relies on the values that reinforce economic aspects; economic drivers are keys to influencing the implementation of sustainable development. Consequently, the new material/solution should have a level of complexity and built-in ability to slowly move toward more complete ESD. Section 2.3 shows that desirable ESD approaches require the full engagement of the affective domain and can instil learners with sustainability values.

Although Chapter 2 provided an overview of sustainable development in Thailand, further empirical studies are required due to the lack of publications on the Thai context and particularly in terms of industrial/product design education. This gap in knowledge forms the basis for investigation into the implementation of ESD in Thai industrial/product design education.

Chapter 3: Research Methodology

3.1 Introduction

Planning the research methodology is crucial to the success of any research project as it enables researchers to keep track of the research and focus on the expected topics. An appropriate research plan also leads to concrete links between the parts of the projects such as data collection methods, samplings, and analysis methods. (Boeije, 2009). In the PhD research, the planning process was commenced from the review of literature. Experts in the field of research design (Robson, 2002; Creswell, 2009) along with other authors (e.g. Boeije, 2009) suggest that researchers should consider some key elements during the planning stage. Figure 15 refers to the 5 elements that were considered when the research planning was configured.

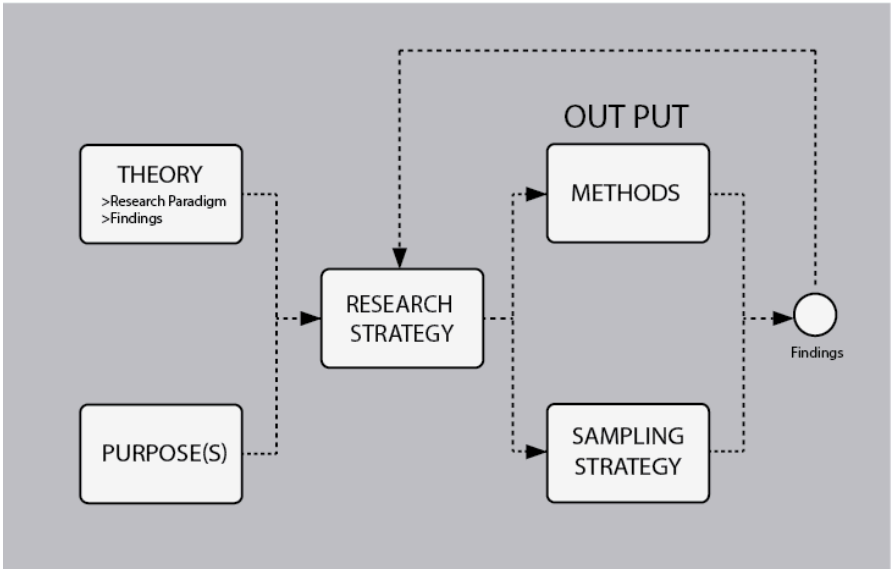


Figure 15: Framework for research design

According to Figure 15, the five elements are research paradigm (3.2), research purpose (3.3), research strategy (3.4), research methods (3.5) and sampling strategy (3.6). The planning process started from identifying the research paradigm and purpose that would enable the researcher to understand the nature of research and to select an appropriate research strategy. The research strategy is a framework of the research project that guides the direction to carry out the research (Yin, 1984). In this PhD project, a flexible strategy was selected to collect qualitative data due to the nature of research that is discussed in sections 3.2 and 3.3. In the next step, the

research strategy was utilised to specify research methods and the way to select samplings. A flexible approach was selected and allowed the researcher to evolve the methodology whilst the research was being carried out. The findings were then developed and used to identify further research methods. This chapter discusses the five research elements and describes an overarching research methodology (3.7) that was built based on these five elements and the findings obtained.

3.2 Research paradigm

The term research paradigm can be defined as *"a basic set of beliefs that guides action"* (Guba, 1990; p. 17) or agreement shared between researchers about how problems can be understood and addressed (Kuhn, 2012). The word 'paradigm' has also been discussed by other authors in the field of research design through different terms such as research worldview (Cresswell, 2009), research theory (Robson, 2002) and epistemologies and ontologies (Crotty, 2003). These authors suggest that identifying a research paradigm is required as it is able to guide and inform when carrying out research studies. Guba and Lincoln (1994) classify and identify research paradigms by dividing them into three parts: ontology, epistemology and methodology. Ontology refers to realities that researchers intend to investigate. Epistemology is the relationship between researchers and the realities. Methodology is a set of selected techniques that are employed in the study. Each paradigm has different characteristics as shown in Table 20 as featured by Harvard University (2008). It presents a list of the 6 common research paradigms that was built up from the works of Creswell (2009), and Guba and Lincoln (1994).

Table 20: A list of the common research paradigms that was created from works of Creswell (2009); and Guba and Lincoln (1994) (Harvard University, 2008).

Research Paradigms	Ontology (What is the nature of reality?)	Epistemology (What is the relationship between the researcher and that being researched?)	Methodology (What is the process of research?)
Positivism (Very rare in qualitative research)	Realism. There is a "real," objective reality that is knowable	Objectivist. The researcher can, and should, avoid any bias or influence on the outcome. Results, if done well, are true.	Tends toward quantification and controlled experiments.
Post-positivism	Critical Realism. There is a "real," objective reality, but humans cannot know it for sure.	Modified Objectivist. The goal is objectivity, but pure objectivity is impossible. Results are "probably" true.	Includes both qualitative and quantitative methods. Seeks reduction of bias through qualitative validity techniques (e.g. triangulation)
Critical Theory	Historical Realism. Reality can be understood, but only as constructed historically and connected to power.	Knowledge is mediated reflectively through the perspective of the researcher.	Focused on investigator/ participant dialogue, uncovering subjugated knowledge and linking it to social critique
Constructivism	Relativist. All truth is "constructed" by humans and situated within a historical moment and social context. Multiple meanings exist in perhaps the same data.	Researcher and participants are linked, constructing knowledge together.	Generally qualitative, research through dialogue.
Advocacy/ Participatory	Varied	The distinction between researcher and researched breaks down. Insider knowledge highly valued.	Works with individuals on empowerment and issues that matter to them. Tends toward social, cultural or political change, using any appropriate method.
Pragmatism	Varied. Pragmatists may be less interested in what "truth" is and more interested in "what works"	Accepts many different viewpoints and works to reconcile those perspectives through pluralistic means	Focuses on a real-world problem, by whatever methods are most appropriate, and tends toward changes in practice.

Using the approaches identified in Table 20, this PhD study can be described as a constructivist paradigm because it is associated with the ontology and epistemology of the paradigm. Firstly, the ESD learning framework is relativist. There are multi-realities as each one is differently built based on specific sociality and culture (Guba and Lincoln, 1994; Robson, 2002). The literature review identified that it has no one-size-fits-all framework for ESD learning due to the difference in context (Tilbury et al., 2007). It also underlined that an understanding of the Thai context was required to develop a new appropriate learning framework.

Table 20 shows that the epistemology of the selected paradigm is realities (frameworks) developed through a process of co-constructions between researcher and participants. Robson (2002) and Creswell (2009) emphasise that cooperation of participants is needed in constructivist research as their views enable researchers to investigate situations and construct realities (frameworks). The findings from Chapter 2 support this position and highlight that the participants' views were necessary because existing frameworks and tools have failed in their implementation as they do not necessarily meet the needs of target users. For example, the Thai Quality Framework for HE (TQF: HEd) (or TQF) is a framework that was used to assess the quality of Thai HEIs and indirectly help lecturers improve their teaching capability. However, its implementation was not successful as it only had one format and was not compatible with disciplines that have different learning cultures (more details in Section 2.8.4).

3.3 Research purpose

Robson (2002) and Boeije (2009) suggest that researchers must have a clear research purpose before carrying out research projects as this enables them to plan and determine research activities. Robson (2002) presents four distinctive research purposes: exploratory, descriptive, explanatory, and emancipatory. Their characteristics are summarised in Table 21.

Table 21: Classification of the purposes of enquiry (Robson, 2002, p. 59)

Exploratory	• To find out what is happening, particularly in little-understood situations. • To seek new insights. • To ask questions. • To assess phenomena in a new light. • To generate idea and hypotheses for future research • Almost exclusively of flexible design
Descriptive	• To portray an accurate profile of persons, events or situations • Requires extensive previous knowledge of the situation etc. to be researched or described, so that the appropriate aspects can be distinguished on which to gather information • May be of flexible and/or fixed design
Explanatory	• Seeks an explanation of a situation or problem, traditionally but not necessarily in the form of a causal relationship • To explain patterns relating to the phenomenon being researched • To identify relationships between aspects of the phenomenon • May be of flexible and/or fixed design
Emancipatory	• To create opportunities and the will to engage in social action • Almost exclusively of flexible design

The literature review indicated the need to develop a new ESD learning framework for Thai product design courses. It discovered that existing frameworks were not being employed in Thai industrial/product design education because they did not meet the needs of stakeholders in the design field, including designers, lecturers, and students. Although the findings from the literature review allowed the researcher to identify the need and problems, the PhD study required further empirical studies owing to the lack of publications relating to a Thai context. Substantial evidence was required to support the findings related to the Thai context presented in Section 2.7 due to the lack of publications specific to Thai undergraduate industrial/product design courses. Gaining insight into the Thai context were mandatory as it enabled the developed framework to identify the

target users and comply with their distinctive needs. Wals (2009) revealed that each country has its own sustainability issues. Thus, information relating to the status of sustainable design was required to enable the framework to be more compatible with the country. Consequently, the purpose of the PhD study was considered as exploratory as it aimed to discover what was happening, seek new insight, ask questions, and assess phenomena (as seen in Table 21). Specifically, the study sought to discover what was happening in Thailand; identify barriers to learning and teaching sustainable design in Thailand; ask questions to people in the design fields and related stakeholders; and assess two phenomena i.e. the status of sustainable design in Thailand and the implementation of ESD in product design education.

3.4 Research strategy

Yin (1994) defines research strategy as the framework of a research project that guides the research direction, including the selection of techniques to gather information and analyse the collected data. Robson (2002) presents two design strategies: fixed and flexible. It is necessary to have substantial understanding of the concept before adopting a fixed strategy as it requires exact pre-specification with all research elements, such as data collection methods, samplings, and analysis methods to be precisely planned and controlled. A fixed strategy is frequently applied in quantitative research based on a single reality that can be measured and quantified. It is also commonly combined with research tools that gather statistical data (Robson, 2002). A flexible strategy is more appropriate to qualitative research as it is less controlling than fixed. It is difficult to fix and plan all research elements in a qualitative study due to its nature. These studies usually deal with the complexity of social interaction (Marshall and Rossman, 1999). Sometimes, researchers are required to investigate a phenomenon that they have little understanding of and cannot predict. Moreover, multi-realities can be built due to differences in social and cultural contexts. While quantitative research focuses on statistical data, qualitative research emphasises achieving quality and in-depth data (Blaxter et al., 2010). This PhD study can be described as a qualitative study as it required an investigation of two major social phenomena: the status of sustainable design in Thailand and implementation of ESD in Thai product design courses. Moreover, the research

paradigm identified in section 3.2 also suggested that the PhD study was defined as qualitative research (as seen in Table 20). A flexible strategy was then adopted to satisfy the research project as this was appropriate to qualitative research and related to the purpose of this research (identified in Section 1.2). A further main reason to implement this flexible strategy was that the researcher had limited insight into the Thai context and could not plan all activities in advance. This strategy allowed the methodology to develop while the project was being carried out.

3.5 Research Methods

As discussed in the previous section, a flexible strategy was employed in this PhD research as it was impossible to plan all research activities ahead of time because of the lack of information related to the Thai context. This section presents the research activities that were included in the first empirical study which aimed to investigate the status of sustainable design implementation in Thailand. Details of additional activities (Phase 4; see Figure 18) are provided in Section 6.3.

3.5.1 Data collection

This section presents the data collection methods used in the first empirical study. Interviewing is a data collection technique that can be applied with an individual interviewee in the form of a conversation (Berg, 2007). It enables the researcher to have full interaction to investigate a participant's experience and knowledge (Bryman, 2001). Robson (2002) divides this research tool into three styles as shown in Table 22.

Table 22: Type and Style of Interviews (Robson, 2002; p. 270)

Types	Descriptions
Fully structured interview	Has predetermined questions with fixed wording, usually in a pre-set order. The use of mainly open-respond questions is the only essential difference from an interview-based survey questionnaire.
Semi-structured interview	Has predetermined questions, but the order can be modified based upon the interviewer's perception of what seems most appropriate. Question wording can be changed and explanations given; particular questions, which seems inappropriate with a particular interviewee, can be omitted, or additional ones included.
Unstructured interview	The interviewer has a general idea of interest and concern, but lets the conversation develop within this area. It can be completely informal.

A semi-structured format was selected because it was appropriate to the empirical study in the second phase that aimed to acquire information related to the Thai context. Firstly, the study required asking some common questions to all participants. A set of questions relating to the basic principles of sustainable design was used to identify the level of understanding. This was imperative to the data analysis as it enabled the reliability of data obtained to be confirmed. Secondly, its flexibility allowed the researcher to modify questions and follow up on unpredicted information that related to the research. The researcher had limited understanding of the Thai context due to the lack of materials available thus allowing the unpredictability to emerge.

3.5.2 Data analysis

Qualitative data is difficult to deal with as it is commonly presented in a text format that has multiple meanings and is more complex than numeric data (Robson, 2002). Moreover, researchers can easily be overwhelmed due to the large amount of data (Miles and Huberman, 1994). Consequently, a process of data management is frequently involved in the analysis for effective data retrieval (Berg, 2007). Experts in the field of research design (Levine, 1985; Wolfe, 1992; Mile and Huberman, 1994; Creswell, 2009) underline that the processes of data analysis and data management are interrelated and have no rigid borderline. This PhD study adopted the analysis

framework introduced by Miles and Huberman (1994) as it emphasises the importance of data management as seen in Figure 16.

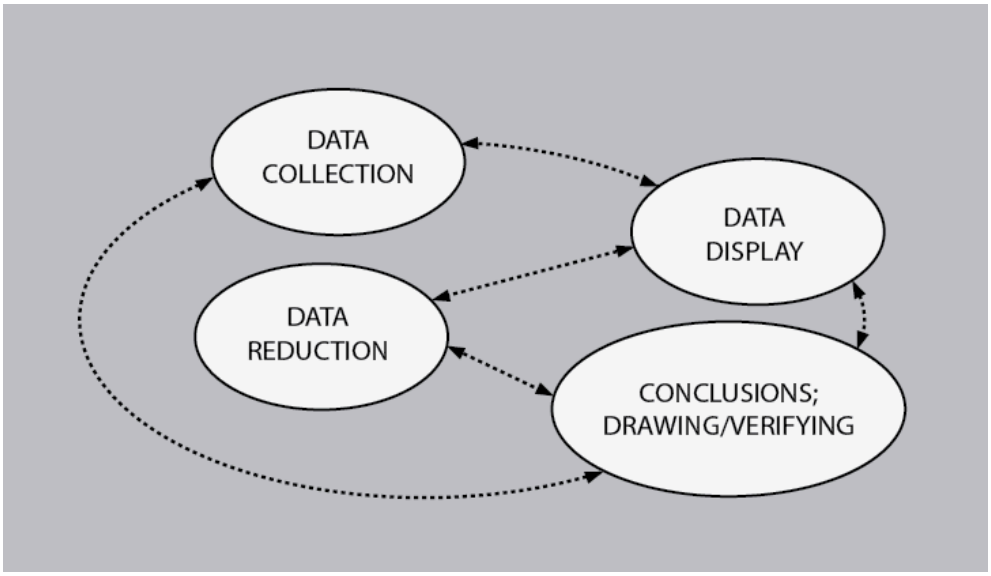


Figure 16: Components of data analysis: Interactive model (Miles and Huberman, 1994)

As shown in Figure 16, the data management in this framework is divided into two functions which are data display and data reduction. Data collection is also one of the framework components as systematic data collection leads to successful data analysis. Along with the data collection, Miles and Huberman (1994) present three concurrent flows of activities:

Data reduction: as discussed in Section 3.5.1, the PhD study mainly collected qualitative data that contained a large amount of text. The first flow is applied within qualitative research as it enables researchers to have more immediate access to the raw data collected (Burg, 2007). The process of reduction refers to data selecting, focusing, simplifying, abstracting, and transforming (Miles and Huberman, 1994; Burg, 2007). Robson (2002) suggests that this process should start in the early stage of data collection to avoid data overload.

Data Display: this second major flow proposes to organise, compress, and bring all selected data together to facilitate the third flow (conclusions drawing). This flow enables the analysis process to be more effective as it simplifies and transforms complex information into displays that are more understandable (Miles and Huberman, 1994). Data can be displayed through different formats such as tables of data, tally sheets of themes and summaries of various statements (Robson, 2002; Burges, 2007). Robson (2002) also notes that the data display can be considered as one of the ways to achieve data reduction.

Conclusions drawing and Verification: Conclusions drawing is usually carried out throughout the research project to elicit meaning from the data. It becomes more definite when all data collection processes have been completed (Burg, 2007). Robson (2002) suggested that it should be accompanied with the verification process that enables the researcher to confirm the reliability of the data.

3.5.3 Coding technique

A coding system was employed in the data analysis of the PhD study as it enabled the researcher to satisfy the processes of data management; data reduction and data display. Coding is a process of labelling tags, names, or descriptions with the data that are pulled out from the raw data. It can be individual words, short phases and/or long paragraphs (Punch, 2009; Robson, 2002). The process also includes categorising selected pieces of data into groups. The overview of the coding process is shown in Figure 17.

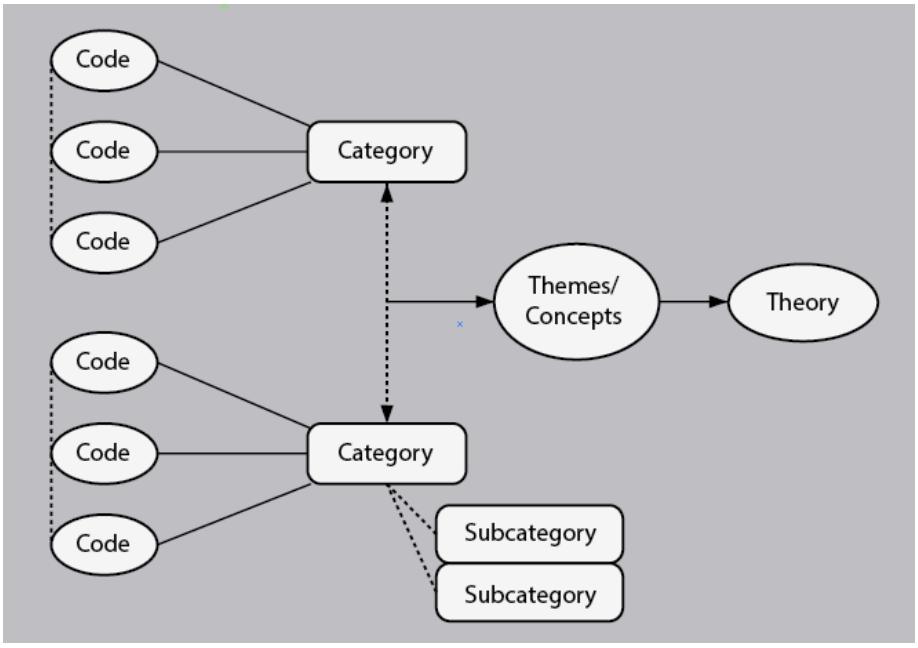


Figure 17: A streamline code to theory model for qualitative inquiry (Saldana, 2009)

Coding has a long history and has been widely used in qualitative studies (Kelle, 1997 cited in Gläser and Laudel, 2011). Consequently, some software packages, such as Nudist or N-Vivo, were developed to support researchers in data management. A significant advantage is time saving; these packages can automatically sort and cluster the data. Although the manual approach is more time consuming, it was selected for this study because it allowed the researcher to gain an in-depth familiarity with the content through continuous reading, re-reading and re-typing. Creswell (2009) considers manual sorting (reading through all the data) as one of the basic steps in data analysis as it provides a general sense of the information. The coding process requires repetition because it can be deemed problematic to have perfect coding in the first attempt (Saldaña, 2009). Qualitative data is usually in text format that has multiple meanings (Miles and Huberman, 1994) and repeating the processes allowed the researcher to re-read and re-analyse, which leads to a higher level of familiarity and data management (Saldaña, 2009). Saldaña (2009), Robson (2002) and Miles and Huberman (1994) divide the coding into two cycles that perform different functions.

The first cycle: is normally applied at the beginning of the analysis because it is simple and direct (Saldaña, 2009). It mainly focuses on attaching labels to groups of words that are related to the research (Robson, 2002). In the first cycle, data classification can happen but it is not compulsory (Punch, 2009) because the whole data collection might not have been completed. Miles and Huberman (1994) suggest that the coding process should be started early to avoid data overload. In this PhD study, the first cycle was related to data reduction (as discussed in section 3.5.2) because it enabled the researcher to summarise the raw data and draw related groups of words together (Punch, 2009). The selected phrases were then used to build the basis for coding in the second cycle. Table 23 presents an example of the list of selected phrases and codes for one of the interviewees in the first cycle.

Table 23: An example of the first cycle coding

Participant code: UNI-1-2	
Codes	Phrases pull out from raw data
Distribution Channel	I agree with the distribution channel of the framework
Sustainable design info	Sustainable design information provided can only be used for the introduction
Web-tool application	Should allow students to access the information section…
Framework structure	The two-sided arrow in the framework should show more repetitive (sic)
Web-design	The design of the web-tool should be more colourful and look more friendly

The second cycle: is more challenging because successful coding requires analytical skills, including classifying, prioritising, synthesizing, abstracting and conceptualising (Saldaña, 2009). In the PhD study, the second cycle was utilised for both data reduction and data display. The sets of data obtained in the first cycle were categorised into a smaller number of groups and more meaningful units (Punch, 2009; Robson, 2002). Examples of the second cycle coding are shown in Table 24.

Table 24: Examples of the second cycle coding

Theme: Usages of the framework		
Participants' codes	Codes	Phases
UNI-1-3-P	Guideline	It can be used as a guideline for teaching sustainable design.
UNI-1-5-N	Guideline	Lecturers can use it as a teaching instruction for sustainable design
UNI-8-1-AD	Teaching preparation	It possibly helps me to select the learning and teaching activities
UNI-1-3-P	Self-reflection	I have engaged my students through these three domains but have never systematically organised. This can help me to reflect what I have done

3.6 Sampling strategy

This section presents the strategy that was used to recruit participants for the empirical studies in Phases 2 and 4. Robson (2002) and Schwandt (2001) present two different sampling approaches: probability and non-probability (or theoretical sampling). The probability approach samples respondents by selecting representatives from the overall population of interest whereas the logic of the theoretical approach is to recruit respondents that are relevant to the research (Robson, 2002; Charmaz, 2006; Schwandt, 2001; Denscombe, 2007). Both approaches can be utilised in qualitative research but this research relied on the latter as it provided greater access to pertinent data (e.g. Charmaz, 2006; Patton, 2002; Glaser and Strauss, 2008). The participants were initially identified through information obtained from the literature review. For example, utilising a list of authors who have published articles related to sustainable design to identify participants. Another approach was to use online curricula to identify participants in the industrial/product design lecture group. In the next step, snowball sampling was utilised to expand the size of the sample groups. This sampling technique can be used to locate hidden populations that are difficult to approach or to find the specific populations (Strauss and Corbin, 1998; Denscombe, 2007). Participants in the empirical studies were asked to assist the researcher to identify other potential participants. Table 25 presents a list of participants that contributed to the data collection.

Table 25: A list of participants

No	Code	Participant's description	Work place
1	GOV-1	Manager	Government agency
2	GOV-2	Manager	Government agency
3	GOV-3	Manager	Government agency
4	COM-1	Owner/Design director	Design company
5	COM-2	Owner/Design director	Design company
6	COM-3	Owner/Design director	Design company
7	COM-4	Manager	Design company
8	UNI-1-1	Lecturer	HEI
9	UNI-1-2	Lecturer	HEI
10	UNI-1-3	Lecturer	HEI
11	UNI-1-4	Dean of faculty/Lecturer	HEI
12	UNI-1-5	Lecturer	HEI
13	UNI-1-6	Lecturer	HEI
14	UNI-1-7	Lecturer	HEI
15	UNI-1-8	Lecturer	HEI
16	UNI-2-1	Lecturer	HEI
17	UNI-2-2	Lecturer	HEI
18	UNI-2-3	Lecturer	HEI
19	UNI-3-1	Lecturer	HEI
20	UNI-3-2	Lecturer	HEI
21	UNI-3-3	Lecturer	HEI
22	UNI-4-1	Programme Leader/ Lecturer	HEI
23	UNI-5-1	Programme Leader/ Lecturer	HEI
24	UNI-6-1	Programme Leader/ Lecturer	HEI
25	UNI-7-1	Programme Leader/ Lecturer	HEI
26	UNI-8-1	Lecturer	HEI
27	UNI-9-1	Lecturer	HEI

As shown in Table 25, participants from three different sectors were invited to the interview sessions to investigate the Thai context. The three sectors were government, business and education, as these can influence the implementation of sustainable design and ESD. Most participants were from the education sector because this research project was focusing on the development of materials that could stimulate the implementation of ESD in Thai undergraduate industrial/product design courses.

3.7 Overview of research methodology

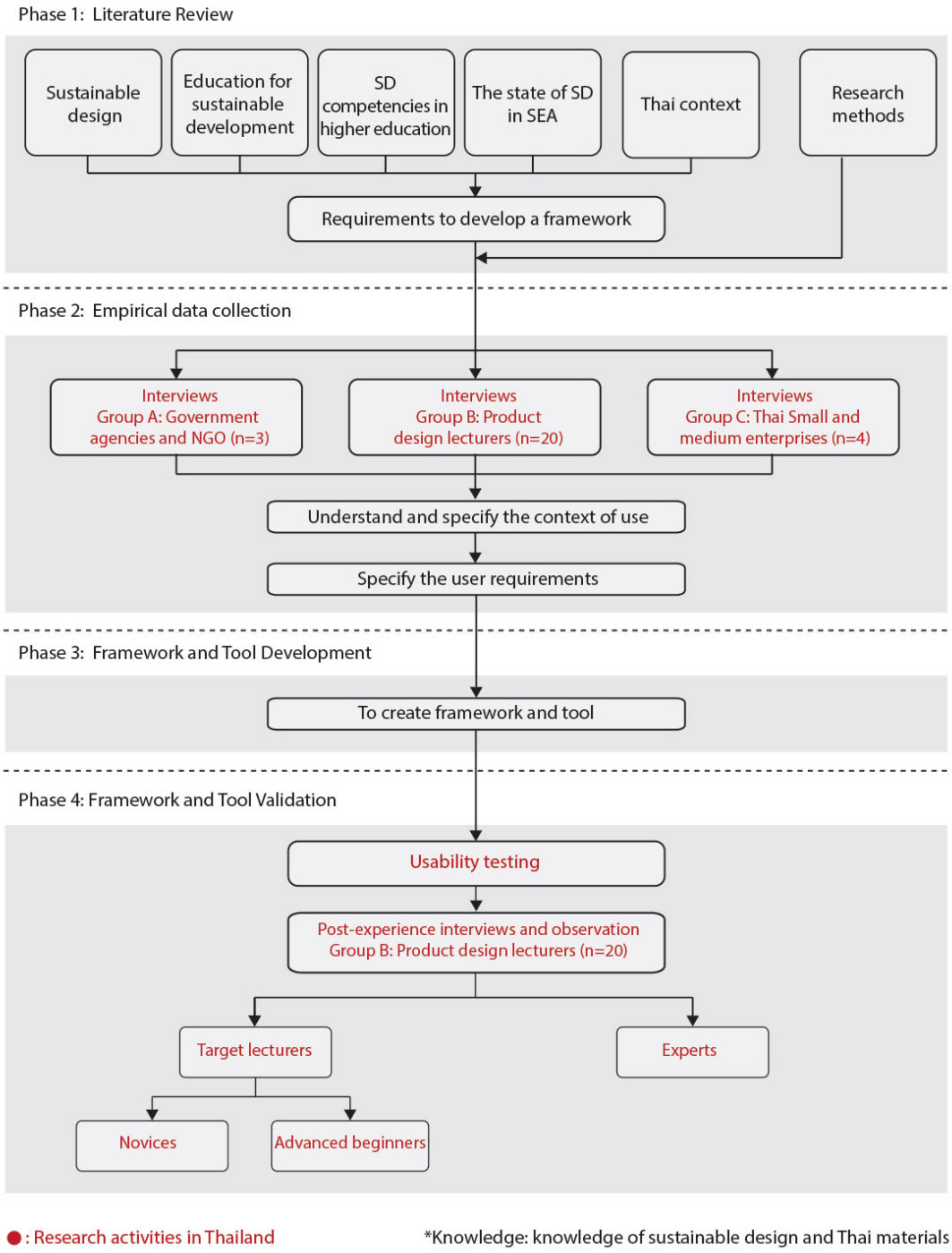


Figure 18: The overview of research methodology

Figure 18 presents the overarching methodology of this PhD project which consisted of four phases. The first phase commenced with a review of literature in related areas: sustainable design (2.2), ESD (2.3), competencies for sustainable design (2.4), the state of sustainable design in South East Asia (2.5) and the Thai context (2.6). Moreover, the review of literature included publications related to research methodology (as presented in Section 3.2-3.6) that enabled the researcher to gain an understanding of the nature of research and indicated appropriate research strategies. The findings from the first phase assisted in the development of other phases in the methodology as discussed in this section.

Phase 2: Empirical data collection

The findings from Chapter 2 indicated the need to understand the Thai context. Thus, Phase 2 initially employed semi-structured interviews to gather qualitative data that allowed the researcher to investigate the status of sustainable design in Thailand. As suggested in Section 3.5.2, data analysis was adopted in the early stage and gave direction for the next research activity. The findings identified that Thai lecturers were the target users of the framework. The sampling size in Group B was then extended to investigate and specify these users' needs. All findings were analysed and utilised to identify the requirements of the framework development as presented in Chapter 4.

Phase 3: Framework and Tool development

The research initially aimed to develop a framework for ESD learning. However, the findings obtained from Phase 2 indicated the need to develop a web-based tool. The findings found that the web-tool was the most appropriate distribution channel due to its benefits. It allows the framework to comply with the learning culture of design that prefers to acquire information through creative materials. The 'SustainAble' web tool was then developed to disseminate and support the developed framework. Details related to the development of the SustainAble tool are discussed in Chapter 5.

Phase 4: Framework and Tool evaluation

Usability testing was employed in the last phase to evaluate the effectiveness and usability of both the framework and the tool. The testing process was required as many existing frameworks and tools have failed in their implementation. In the testing process, the participants, including target lecturers and experts, were exposed to the developed framework to provide feedback which was collected through interview and observation techniques. The findings were then utilised to assess the effectiveness of the framework and the web-tool and to also provide suggestions for further development.

3.8 Ethical consideration

Many guideline books (e.g. Webster et al., 2013; Bryman, 2012; Denscombe, 2007) for qualitative research methods emphasise the need to take account of research ethics and suggest researchers consider ethics in the early stages of their research projects. Researchers are required to respect the rights of all participants and treat them well during all research activities (Webster et al., 2013; Denscombe, 2007). Webster et al. (2013) lists basic ethical issues for most social science research projects:

- Participation should be voluntary and free from coercion or pressure
- Research should not make unreasonable demands on participants
- Participation in research should be based on informed consent
- Confidentiality and anonymity should be respected

All these were adhered in the research activities of this PhD project. Before the empirical studies were carried out, a PowerPoint presentation (see Appendix D) was sent out to the expected participants including experts in the Thai design industry, government agencies, and industrial/product design lecturers. The presentation provided them with an overview of the research project, research aim and objectives and the required procedure of the participants' roles. The participants were required to sign a consent form (see Appendix E) to confirm that they were willing to participate in the research activities.

Moreover, to ensure rights of privacy and confidentiality of the participants, all personal details were kept anonymous. An acronym referring to each participant (see Table 25) was given while carrying out the data analysis and when presenting the findings in public.

Chapter 4: The implementation of Education for Sustainable Development (ESD) in Thailand

4.1 Introduction

A significant number of ESD tools and frameworks are available, but they cannot be effectively adopted in the Thai education system because they have not been developed to meet the distinctive needs of the Thai context. As discussed in Chapter 2, each country has different sustainability challenges or issues based on its cultural, environmental and policy context (Wals, 2009). Although the literature review provides an overview of sustainable development in Thailand, there was a lack of research relating to the implementation of ESD in Thai industrial/product design courses. To increase the level of understanding in this area, interviews with the government agencies, industry experts and product design lecturers were carried out to investigate the current state of ESD implementation in Thai product design education. This chapter reveals the findings from interviews with three groups of stakeholders (an example of an interview transcript is provided in Appendix F). It explores the current state of ESD in the government sector (Section 4.1.1) and business sector (Section 4.1.2). The chapter also presents the progress of ESD implementation in industrial/product design education in three sections: Overview of ESD implementation in Thai industrial/product design courses (Section 4.2); Thai industrial/product design lecturers (Section 4.3); Barriers to the implementation of ESD in Thai industrial/product design education (Section 4.5).

4.1.1 Government sector

This section presents findings from interviews with three experts from the government sector (group A) and three lecturers that have been involved in government initiatives. All participants agreed with the findings from the literature review that a traditional education system contributes to unsustainable development as it focuses solely on economic issues (Sterling, 2004). The interviewees revealed that all companies in the Thai manufacturing industry have developed products based on an economic approach, where the generation of revenue is a key factor in decision-making for all processes of product development.

> *"Designers can influence products to be more sustainable but they give little interest to help the world as Thai designers have been educated to focus on economics"* (UNI-2-1).

The Thai government has started to build an awareness of sustainability and educate Thai entrepreneurs to have greater understanding of sustainability through a number of initiatives such as the TGDN, Thai RoHS and Learn Online (more details provided in Section 2.7). Although ESD learning and teaching requires a holistic view of the TBL, Chapter 2 identified that Thailand has emphasised eco-design due to business drivers (section 2.7) and the influence of ASEAN (section 2.6.1). Moreover, the findings from the interviews revealed that existing initiatives have focused on environmental sustainability because the implementation of sustainable design in the country started from eco-design.

> *"In Thailand, we started to educate people by starting from 'eco-design' that is merged between economic and ecology. Normally, designers usually consider cost and function. The concept encourages them to incorporate environmental issues into products"* (GOV-1).

Moreover, the experts (GOV-1, GOV-2) from the government agencies and the lecturers (UNI-1-6, UNI-2-1) revealed that most of the main contributors in the agencies were in the field of engineering. They integrated sustainable design by stressing environmental sustainability (or eco-design) as the progress of eco-design implementation can be numerically assessed through the carbon footprint. As discussed in Section 2.8, some government initiatives have targeted undergraduate students both directly and indirectly. However, the interviews with participants from the government sector (GOV-1, GOV-2) identified that government agencies focus on the business sector and have decreased the number of educational initiatives due to financial constraints. For example, the Eco-design Award (as discussed in section 2.8.1) is no longer available at an undergraduate level. Moreover, one of the course developers from Learn Online (as discussed in section 2.8.2) revealed that although the courses are still available, seminar sections have been cancelled and there will be no updates of the information. Although design students might utilise eco-design

information from initiatives as this can be accessed via the internet, design lecturers that are involved with the initiatives (UNI-1-6, UNI-2-1) mentioned that the content was too complex for design students as it had been developed from an engineering perspective.

> "*Life cycle assessment is not for design students. It requires user[s] to understand complex equation[s] and numeric numbers. Designers only need to know about life cycle thinking*" (UNI-2-1).

The interviews identified that most researchers who had been involved in eco-design initiatives had obtained their degree from an engineering department.

The Thai Creative and Design Centre (TCDC) is a government agency that emphasises the importance of integrating design into business. A manager mentioned that it has launched some initiatives that contain content related to social and environmental issues. For example, TCDC provided a contribution to the product development of OTOP by encouraging collaboration between designers and local communities. Moreover, some related books were provided to the TCDC libraries that have over 25000 design books and 250 titles of design magazines and journals (TCDC, 2012). According to the interview, students were the largest proportion of TCDC library members and were the main participants in the design workshops (GOV-3). However, accessibility to the information remains an important issue for Thai students as the libraries were only available in Bangkok and Chiang-mai. Although some books were available in Thai, most of them were in English. Wiriyachitra, (2002) found that the English proficiency of Thai citizens was relatively low in comparison to other countries in Asia. The manager also revealed that the agency aimed to create an awareness of design but was not ready to launch any specific ESD initiatives due to financial constraints and the time required (GOV-3). Although the government did recognise the importance of ESD, it appears that they did not give priority to the education sector due to the lack of time and budget.

4.1.2 Business sector

This section presents the findings from interviews with five Thai design companies that have successfully integrated sustainable design or eco-design. All of them have successfully traded products in the international market and have been awarded prizes for good design (e.g. Good Design Award (G-Mark) from the Japanese government and Design Excellent Award (DE-mark) from the Thai government). The interviews also confirmed that all these participants have an insight into eco-design or sustainable design. They were able to clearly explain and discuss the concepts through their designs.

> "We *use water hyacinth that is biodegradable material and unwanted. Our production processes are based on handicraft that does not require much energy*" (COM-3).

Although the findings from the literature review classified sustainable design activities in Thailand into three groups (eco-design, local product development, sufficiency economy) the interviews indicated that most participants focused on eco-design. Four out of five gave priority to environmental sustainability and used the word *"eco-friendly"* to represent their products. There was one company that based on industrial craft production and required the use of indigenous knowledge and a local workforce. It also performed as an original equipment manufacturer (OEM) that produced products for other companies.

Four out of the five participants played two essential roles of design and management. All the designers had an awareness of the environmental problems and supported the integration of eco-design. However, business drivers were the main factors that encouraged them to implement sustainable design (or eco-design). As discussed in Chapter 2, integrating the two can provide companies with various benefits such as lower production costs, increased product benefits, and new market opportunities (Bhamra, 2007). This was also indicated in the findings from the interviews, where most participants selected recycled or waste materials as they intended to reduce the production cost or create unique selling points. For example, one of the criteria to develop products like "The Remaker" is to use waste materials

such as tyres, unwanted clothes, and used PVC printed banners as shown in Figure 19 (TCDC, 2013).

Figure 19: *The Remaker* product made from a used PVC banner

The CEO of the company that applies indigenous knowledge into its production discovered that "*I did not want to preserve the Thai culture but I saw an opportunity to create unique products that are difficult to produce in Europe due to high labour cost*" (COM-3). They also discovered that most of their eco-products were sold internationally. However, recent sales figures suggested an increasing demand from local consumers. This was because the importance of eco-design was considered as becoming more acknowledged as it has been promoted through mass media, such as television, radio, and newspapers. Consequently, many other Thai companies have attempted to claim that their products are environmentally friendly. Nevertheless, the findings from the interviews revealed that most Thai companies had failed to implement the concept due to a lack of understanding of the product life cycle. As discussed in Chapter 2, eco-design requires consideration of the entire processes of cradle to grave (Bhamra, 2007). However, the interviews indicated that Thai designers typically address a single environmental issue which may then create other negative impacts. A design expert mentioned that

"*many designers have the mindset that plastic is not good for nature. Some of them have then selected composite materials that can result in negative environmental impacts as the materials require chemical treatment and could not be recycled*" (COM-4).

All the selected companies supported the learning and teaching of ESD in Thai HE through various activities. Some of the designers had been guest lecturers to share their sustainable design (or eco-design) experience on product design courses. Moreover, one of the participants (COM-5) had cooperated with a non-profit organisation called Mae Fah Luang Foundation[4]. They organised sustainable design camps that provide undergraduate students with knowledge on sustainable design and opportunities to practice this through supported projects (Doi-tung, 2009a).

Figure 20: An example of a water saving vase from the 2010 Cotto sustainable design camp

Although the companies have provided some support to HE, they did not expect any capability in sustainable design from recent graduates, as they believed that sustainable design literacy could be gained through working experience*: "It is good to have but they can learn on the job"* (COM-1)

"*I do not require any specific skills, they can learn through experience. I think all new designers [are] aware of this concept but they do not have*

[4] The foundation is a private and non-profit organisation that was established by Her Royal Highness Princess Srinagarindra (Doi-tung, 2009b).

opportunities to practice because Thailand has only [a] few eco-design companies" (COM-2).

These findings from the interviews confirmed the statement of Lindahl (2008) that most Thais who were working on eco-product development did not obtain eco-design knowledge from their undergraduate degree but acquired it from other channels. All participants from the Thai design industry also revealed that they had obtained sustainable design knowledge and skills through working experience. For example, one participant said, "*I have cooperated with the National Innovation Agency (NIA) to develop a new material for 2 years; this provided me with the knowledge to develop eco-composite materials*" (COM-2).

4.2 Overview of ESD implementation in Thai industrial/product design education

As mentioned in Chapter 3, an interview method was employed to address the shortfall of literature relating to the implementation of ESD in Thai industrial/product design education. The internet was initially utilised for the interview preparation; it facilitated the researcher to acquire basic information of the participants (lecturers) through online curricula. During the preparation, the researcher found that most of the design courses have provided their curricula online, which were then collected and used to investigate the current state of ESD implementation in Thai industrial/product design education. The investigation started by reviewing the universities' websites; the list of Thai HEIs was retrieved from the website of the Office of Higher Education (OHEC, n.d.). According to the directory, 171 Thai HEIs have been registered in 2014. The curricula review discloses that 59 industrial/product design courses were offered (see Appendix A). 43 out of 59 have provided their courses information through their websites. The details were compiled in the curriculum review sheets (see Appendix B) that were used for the analysis. This section discusses the implementation of ESD in Thai industrial/product design courses based on the composite finding obtained from the curricula review and interviews with industrial/product design lecturers. It starts by giving an overview of Thai industrial/product design courses and where sustainable design is

taught (Section 4.2.1). The section then presents teaching strategies that have been employed (Section 4.2.4) and the use of output approaches (4.2.3).

4.2.1 Thai industrial/product design courses

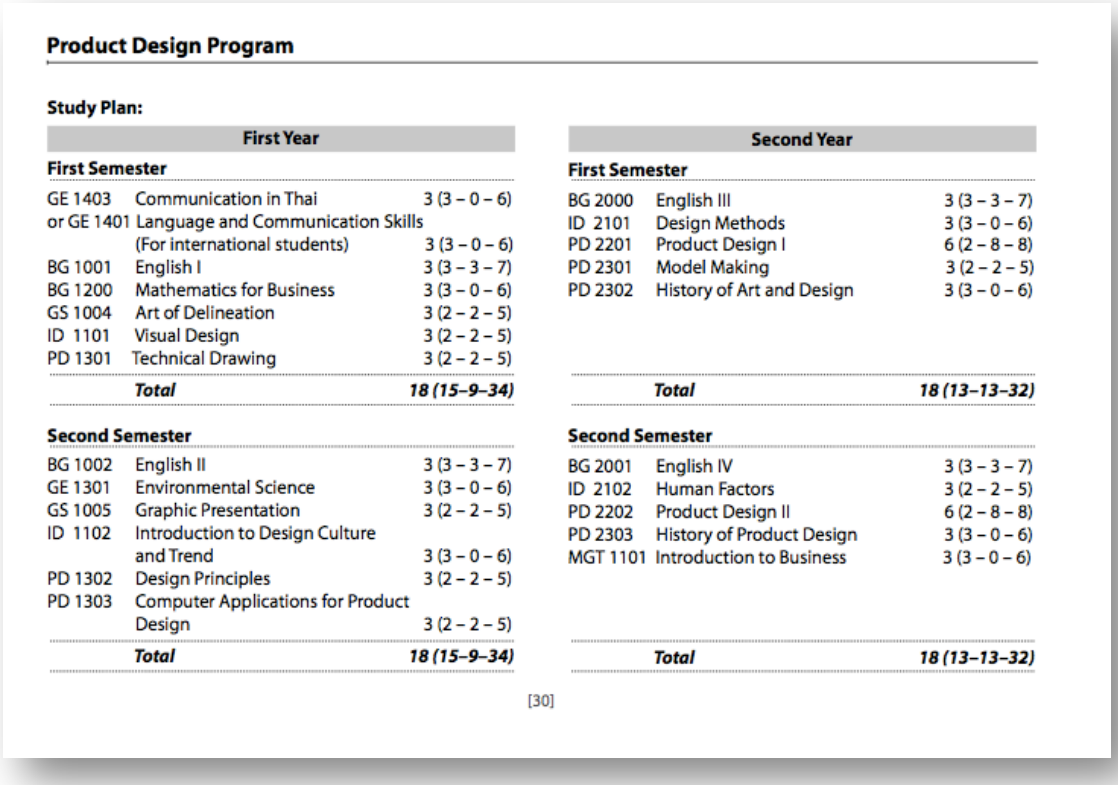
The literature review showed that Thailand has focused more on design and the role of product designers due to the results from the economic crisis in 1997. The Thai government believes that creativity enables the Thai manufacturing industry to be more competitive in the international market and stimulate the economy (TCDC, 2012). TCDC was then established in 2004 to promote the need of integrating design in businesses. Moreover, the government has launched the OTOP scheme that encourages Thai communities to develop their own products (Section 2.7.1.2). These situations have influenced demand for industrial/product design professionals in the Thai manufacturing industry. Findings from curricula reviews indicated a dramatic increase of industrial/product design courses in Thailand. According to the curricula review, over 30 new product design degrees have been introduced since the beginning of the 21st century. Although all the industrial/product design courses are designed to satisfy the demand of industry and teach product design, they have differences in details as shown in Table 26.

Table 26: Thai industrial/product design course details

Faculty Name	Degree Name	Duration (year)
Fine & Applied Arts	Bachelor of Fine and Applied Arts (Product Design)	4
Architecture	Bachelor of Industrial Design	4 (5)
Architecture	Bachelor of Architecture (Industrial design)	5
Decorative Art	Bachelor of Art	4
Science and Technology	Bachelor of Science (Industrial Product Design)	4
Social Science	Bachelor of Art	4
Liberal Arts and Science	Bachelor of Science (Industrial Product Design)	4
Industrial Technology	Bachelor of Architecture	5
Engineering & Architecture	Bachelor of Architecture in Industrial Design	5

Firstly, degrees were named based on the faculties where they are taught. An example shown in Table 26, the Bachelor of Science (Industrial Product Design) was offered in the faculty of Science and Technology. Secondly, all product design courses in the Faculty of Architecture were five-year programmes while other faculties offer four-year programmes. However, some universities have changed from five to four-year programmes in recent years (2012-2014). Along with 4-5 year courses, the review shows that some HEIs offer two-year (continue programme) product design courses which are available for students who have achieved vocational diplomas in the related fields.

According to the curricula review, most of the HEIs offered 4-year programmes (with two semesters in each academic year). Undergraduate students on average were required to complete 135 learning credits. Allocated credits of each module in product design courses varies and ranges from 2 to 8 credits. The credit allocation relies on the amount of learning content and activities of the module. The numbers of credits are usually provided in the course outlines and come together with three numbers as shown in Figure 21.



Product Design Program

Study Plan:

First Year			Second Year		
First Semester			**First Semester**		
GE 1403	Communication in Thai	3 (3 – 0 – 6)	BG 2000	English III	3 (3 – 3 – 7)
or GE 1401	Language and Communication Skills (For international students)	3 (3 – 0 – 6)	ID 2101	Design Methods	3 (3 – 0 – 6)
BG 1001	English I	3 (3 – 3 – 7)	PD 2201	Product Design I	6 (2 – 8 – 8)
BG 1200	Mathematics for Business	3 (3 – 0 – 6)	PD 2301	Model Making	3 (2 – 2 – 5)
GS 1004	Art of Delineation	3 (2 – 2 – 5)	PD 2302	History of Art and Design	3 (3 – 0 – 6)
ID 1101	Visual Design	3 (2 – 2 – 5)			
PD 1301	Technical Drawing	3 (2 – 2 – 5)			
	Total	***18 (15–9–34)***		***Total***	***18 (13–13–32)***
Second Semester			**Second Semester**		
BG 1002	English II	3 (3 – 3 – 7)	BG 2001	English IV	3 (3 – 3 – 7)
GE 1301	Environmental Science	3 (3 – 0 – 6)	ID 2102	Human Factors	3 (2 – 2 – 5)
GS 1005	Graphic Presentation	3 (2 – 2 – 5)	PD 2202	Product Design II	6 (2 – 8 – 8)
ID 1102	Introduction to Design Culture and Trend	3 (3 – 0 – 6)	PD 2303	History of Product Design	3 (3 – 0 – 6)
PD 1302	Design Principles	3 (2 – 2 – 5)	MGT 1101	Introduction to Business	3 (3 – 0 – 6)
PD 1303	Computer Applications for Product Design	3 (2 – 2 – 5)			
	Total	***18 (15–9–34)***		***Total***	***18 (13–13–32)***

[30]

Figure 21: An example of product design course outline (Assumption University, 2014)

Learning activities in each module are categorised into three groups: lecture, laboratory, and self-study. The module code (credit number and others) is used to indicate required hours per week of activities in each group. For example, sustainable design 3(2-2-6) refers to 3 credit modules that require 2 hours for lectures, 2 hours for laboratory work and 6 hours for self-learning per week. The average duration of each semester is 18 weeks. The findings from the curricula review discovered that many Thai institutions were aware of sustainability issues as reflected from the information provided in their websites. Issues related to sustainable development were included in the 'about' page of HEIs' websites in various forms such as aim and objectives, vision and mission, and course descriptions. Some examples of the statements are provided in Table 27.

Table 27: Examples of HEIs that include sustainability as aims and/or objectives

HEIs	Statements that show HEIs' intentions to implement ESD
KKU	Enabling undergraduates to have the moral, ethics, and vision to reinforce sustainable development Enabling undergraduates to have ability in applying design
KMUTT	Motivate students to be socially responsible by providing a strong basic foundation of intellectual, moral, ethical and spiritual aspects for the design for all humanity
NU	The Faculty of Architecture, Naresuan University, has engaged in nurturing quality architects and designers since our founding days. All programs offered in our Faculty are directed toward sustainability and sustainable development.

The curricula review also shows that modules related to sustainability were taught in Thai industrial/product design education. According to the Ministry of Education (2015), modules in Thai HE are categorised into three groups; general education modules, specialised modules and elective modules. The curricula review found that modules that related to sustainability were included in the first two groups. The following sections discuss the modules in more detail by grouping them based on their types: general education modules (4.2.2) and specialised modules (4.2.3).

4.2.2 General education modules

According to the curricula review, modules contained in this group were not specifically developed for industrial/product designers but they are important to the design students. The general education modules are available to all students in the HEIs. According to the Ministry of Education (2015) the modules in this group aim to enable learners to survive and live with others in society; and to have a broad knowledge and respect the values of others. The findings from the review indicate that the knowledge provided in this group involves a wide range of subjects from different fields such as social sciences, humanities, mathematics, and languages. 30 credits from modules in this group is one of the requirements to acquire bachelor degrees in Thai HE (Ministry of Education, 2015). The reviews found that the content related to sustainable development were taught in the modules in this group, as shown in Table 28.

Table 28: Classification of modules in the general education group (concluded from the curricula review)

TBL	Topics	Examples of modules (see more in Appendix B)
Social aspect	Living in the society and ethics	- Human and society (L) - Man and Ethics of Living (L) - Ethics (L) - Law and Professional Ethics (L) - Thai Ideal Graduate (L) - Our Community (L)
	Conservation of Thai culture	- Local wisdom (L) - Language, Society and Culture (L) - Art and Design in Thai Society (L) - History of Thai Arts (L) - Thai Living (L) - Lanna (North of Thailand) Studies (L) - Bangpakong Studies (L)
	ASEAN	- Art in ASEAN Culture (L) - Contemporary South East Asia (L)
Economic aspect	Sufficient economy	- The Philosophy of Sufficiency Economy (L) - To Follow in the Royal Foot Steps of His Majesty the King (L)
Environmental aspect	Conservation of Natural resource	- Environmental science for sustainable world (L) - Human and Environment (L) - Environmental study (L) - Natural Resource Conservation (L) - Environment and Resources Management (L) - Environment and Living (L)
Remark: (L) lecture based module, (S) studio based module, and (L/S)		

As seen in Table 28, sustainability modules in this group can be categorised according to sustainability aspects: social, economic and environmental aspects. Among the three groups, social sustainability was the most varied and covers learning topics that can be grouped into three sub-groups: living in the society and ethics; conservation of Thai culture; and ASEAN. In addition, the review found that there was no module that emphasises the holistic view of TBL in this group; all of them only stress one or two sustainability aspects. In addition, the findings from interviews showed that more general education modules related to sustainable design have been introduced into Thai HE (e.g. on topics such as the sufficiency economy and humans and the environment).

4.2.3 Specialised modules

Modules in this group were specifically developed for industrial/product design students in each course. According to the Ministry of Education (2015), the specialised modules aim to enable learners to acquire knowledge in specific areas and capability to work in their future occupations. 72 and 90 credits from the specialised modules are required to finish four and five-year undergraduate courses, respectively (Ministry of Education, 2015). The review shows that the specialised modules consist of both lecture-based and studio-based ones. Four-year courses require students to complete at least 24 credits from lecture-based modules and 36 from studio-based ones (Ministry of Education, 2015). The curricula review discovered that modules related to sustainability were also available in the specialised education group as shown in Table 29.

Table 29: Classification of modules in the specialised education group (conclude from the curricula review)

TBL	Topics	Examples of modules (see more in Appendix B)
Social aspect	Thai indigenous knowledge	- Isan Arts and Crafts Preservation (S) - Isan Ornament Design (S) - Industrial Art & Craft Fieldtrip (L/S) - Local Product design & Development (n/a) - Applied Art Design for Thai Identity (L/S) - Thai Wisdom and Local Arts (L/S) - Thai wisdom for innovative design (L) - Thai Product Design (L/S) - History of Thai Arts
	Ethics	- Moral, Legal and Professional Practice (L) - Professional Ethics (L)
	ASEAN	- Asian Culture for Service Design (S) - History of Art and Design in Asian (L) - Product design in ASEAN community (L/S) - Art Design in Southeast Asia (S) - Art in ASEAN Culture (L) - Contemporary South East Asia (L)
Environmental aspect		- Development and Analysis of Natural Materials (L/S) - Product Life Cycle - Eco Product Design
Holistic view	Sustainable design	- Sustainable design (L/S) - Sustainability in Product design (L/S)
Remark: (L) lecture based module, (S) studio based modules, and (L/S)		

Table 29 presents modules related to sustainability by grouping based on their main focuses on sustainability aspects. Firstly, social sustainability modules, were the most varied and cover a wide range of topics. The second group is modules related to environmental sustainability. Although Chapter 2 showed that Thailand has a strong tradition in EE, the curricula review shows that only a few environmental sustainability modules were included in the curricula. Lastly, only 6 out of 43 curricula showed that sustainable design modules were involved in industrial/product design courses as shown in Table 30.

Table 30: Description of sustainable design modules (specialised modules) in Thai undergraduate industrial/product design courses.

HEI	Module's name And credits	Module description
KMUTT	Sustainable Design 3(2-2-6)	Principles of Sustainability: Planet, People and Profit. Importance of sustainable development. Roles and responsibility as individuals and designers towards sustainable development. Different sustainable design approaches. Application of sustainable design knowledge into practice.
KKU	Sustainable design 3(2-2-6)	Environmental impact of industrial development, sustainable design principles, product life cycle, 3R principles (reduce, reuse, recycle), green products, utilization of vernacular intellect for sustainable design.
KSU	Sustainable design 3(2-2-5)	A study of concepts and practice of design with environmental concerns, product life cycle and other relevant factors, eco-design, regulations on environment relating to design practice for sustainable development, design for sustainability, sustainable future.
RSU	Product design for sustainability 4(1-6-5)	Concepts and processes of product design that concern environmental effects, the use of materials and production processes. Development of creative products that respond to environmental concepts for sustainability in society and product design business.
KBU	Sustainability in product design 3(2-2-5)	Not provided
SKRU	Sustainable design 3(2-2-5)	Not provided

The module descriptions displayed in Table 30 show that the sustainable design modules aimed to teach students the basic principles of sustainable design. This finding was also confirmed through the findings from interviews; three sustainable design lecturers revealed that the modules only provide the basic level of sustainable design. The module codes provided in the curricula refer to most of the modules that equally employ lecture-based and studio-based classes. For example,

in sustainable design 3(2-2-5) the module allocates 2 hours per week for both lectures and practice of sustainable design. But the interviews found that all the lecturers consider the modules more like lecture-based modules as they contain lots of lectures when compared to other studio-based modules. The interviews found that Thai industrial/product design education had a tendency to offer more sustainable design modules. The findings found that two HEIs had planned to introduce sustainable design modules in their courses and three had shifted the modules from elective (optional) to compulsory due to the drive from the design lecturers.

Along with the modules that show their attention to teaching topics related to sustainability (included in the modules' descriptions), the interviews with industrial/product design lecturers showed that sustainability topics had also been taught through other design modules. The findings showed that social enterprise (SE) and design for communities were taught in industrial design modules at King's Mongkut Institute of Technology, Ladkrabang (KMITL). Although the curricula review indicated that social sustainability was given greater priority and only a few eco-design modules were offered, the interviews revealed that the content relating to environmental sustainability frequently appeared in other design modules, such as industrial design, furniture design and packaging design. In addition, even though the mainstream and sustainable economy are different, most Thai lecturers gave little consideration to the economic aspect of sustainability. This issue was noted by a lecturer in the expert group (UNI-1-2) and confirmed through the interviews with 18 lecturers in the rest of the three groups (more details about the classification of lecturers are provided in Section 4.3.1). The 18 lecturers revealed that they taught the concepts related to sustainable design in their classes. Some examples of learning content were drawn on during the interview sessions but none of them were associated with the economic aspect.

4.2.2 ESD Teaching strategies

As illustrated in the previous section, sustainable design knowledge and skills have been transferred through different forms. Remirez (2012) found that sustainability learning in industrial/product design courses were usually taught though lecture-

based and studio-based learning. The curricula review and interviews also show the similar result, the modules related to sustainability require students to attend lectures and/or laboratories, which can refer to lecture-based and studio-based learning, respectively. This section then discusses learning and teaching strategies employed in the modules based on the uses of the two learning types: lecture-based modules (Section 4.2.2.1), lecture-based modules with active learning activities (Section 4.2.2.2), and studio-based modules (Section 4.2.2.3).

4.2.2.1 Lecture-based modules (Traditional approach)

This section discussed modules that teach topics related to sustainable development through traditional lectures, which are a one-way learning where students receive the message delivered by lecturers with little interaction (see Section 2.6.2.2). The curricula review shows that most of the general education modules (Section 4.2.2) were lecture-based as illustrated in Table 31.

Table 31: Examples of general education modules that taught sustainable design

HEI	Modules Name	Module Code
KKU	Civic Social Engagement	3(3-0-6)
KKU	Local Wisdom	3(3-0-6)
DRU	Natural Resources and Environmental Management	3(3-0-6)
NSRU	Life and Environment	2(2-0-4)
KBU	Environmental Science for a Sustainable World	2(2-0-4)

As seen in Table 31, the modules' codes show that students were not required to attend any laboratory. They only had to attend 2 or 3 hours of lectures per week.

The findings from interviews support the literature review that lecture-based learning is widely employed in the Thai HE system owing to its advantages in maximising resources including time, budget, and lecturers. The interviews revealed that teaching sustainability in the general education modules can address the problem of the lack of lecturers with ESD qualifications and other limited resources.

"The time provided in a module is too little to teach sustainability. But students can acquire some related knowledge like sufficien[cy] economy though general education modules (UNI-5-1)"

"Our department lacks lecturers with eco-design qualifications. We need to send our students to attend basic eco-design course to the environmental science department (UNI-6-1)"

However, the interviews discovered that most design students could not effectively obtain information from the general education group modules as they were not compatible with industrial/product design students' needs. Firstly, Section 2.6.2.2 showed that in some cases the lecture method can be adapted to satisfy the needs of specific audiences. However, most of the lecturers were not from industrial and product design courses and could not understand the learning culture of design students who, according to Bhamra and Lofthouse (2003), require specific ways to acquire knowledge. Secondly, learning content in the modules was complex and not appropriate for design students. The findings from interviews discovered that most of the general education modules were taught in other faculties. Modules related to environmental sustainability were usually taught in the faculty of science or engineering. Thus, the learning content were selected based on the needs of students in the faculties and might also involve some content that is not appropriate for the design students (e.g. complex jargon and equations)."*Design students are only required to understand about product life cycle not the complex equations of LCA* (UNI-2-1)"

4.2.2.2 Lecture-based modules with active learning activities

As mentioned in Section 2.6.2.2, it is suggested that lecturers include interactive activities to address the lack of interaction and enhance retention rates. The curricula review found that many specialised modules equally employed lecture and studio learning as illustrated through the module codes presented in Table 32.

Table 32: Examples of specialised modules that taught sustainable design

HEI	Modules Name	Module Code
URU	Local Handicraft Product Design for Muang-Ta-Nua	3(2-2-5)
SRU	Folk Craft Product Design	3(2-2-5)
PKRU	Product Design in Thai Style	3(2-2-5)
ARU	Thai Lacquering Product Design	3(2-2-5)
KSU	Thai Product Design	3(2-2-5)

In addition, most of the sustainable design modules (presented in Table 32) also employ lecture-based modules with active learning activities. However, according to the interviews, although the modules equally utilised both lecture and studio classes, they were considered as lecture-based modules as the they only provided a few interactive activities when compared to other design modules that were studio-based. The interviews found that lecture-based modules in this category were more suitable to product design students than the general education group. Because they were developed for product designers and, as such, complied with the learning culture of designers. The findings from the interviews showed some uses of active learning strategies mentioned in Section 2.6.2.2 as illustrated in Table 33.

Table 33: Examples of use of active learning in lecture-based modules

Active learning strategies	How they were used in the classes
Discussion	Seven out of nineteen participants in the design lecturers' group revealed that they employed discussion sessions to encourage students to think critically and move away from being passive receivers.
Stimulate activity	Some visual learning materials were utilised to fulfil the activities (e.g. sustainable design video clips and carbon footprint calculators.
Expert speech	A lecturer allocated a few classes for expert speakers. A sustainable design specialist (lecturer) and sustainable product designer were invited to teach in the classes
Small design project	Students were assigned to carry out small design projects that only required a short period of time (3-4 classes).

Two participants that were responsible for sustainable design modules agreed that active learning strategies can effectively contribute to the learning and teaching of sustainable design. They also show intentions to add more active learning strategies and shift from lecture-based to studio-based modules that had more interactive activities.

However, the interviews indicated that 5 of the design lecturers preferred to use traditional lectures to teach sustainability and resisted active learning strategies. They felt that the new approach was not applicable to some groups of students. The lecturers revealed that many Thai students did not pay attention and did not sufficiently engage in learning activities because they were more familiar with the traditional lecture.

"I have tried to apply a student centre approach; I assigned students to carry out some research and discuss the findings in my class. Most of the students keep quiet. Only a few students participated in the activities" (UNI-7-1)

4.2.2.3 Studio-based modules

According to the findings from the interviews, the modules that give focus to laboratory work (see the modules codes shown in Table 34) were considered as studio-based modules in Thai industrial/product design courses. The curricula review shows that topics related to sustainable design were also taught through studio-based modules.

Table 34: Examples of studio-based modules that taught sustainable design

HEI	Modules Name	Module Code
RSU	Thai Culture and Local Wisdom in Product Design	4(1-6-5)
KKU	Esan Arts and Crafts Preservation	3(1-4-3)
BU	Asian culture for service design	3(1-4-4)

Findings from the curricula review and interviews indicated that most of the studio-based modules were taught without the full consideration of TBL (economic, environmental, social aspects) as they gave priority to social or environmental

aspects but not both. According to the course outlines, most of the modules that were associated with sustainability focused on social sustainability. The interviews underpinned the findings from the curricula review and found that the conservation of Thai culture was the predominant topic of the social aspect. The findings from interviews also showed that the topics of social enterprise (SE) and design for communities appeared in the studio-based modules. Although the curricula review implied that social sustainability was given greater priority and only a few eco-design modules were offered, the interviews revealed that the content relating to environmental sustainability frequently appeared in other design modules, such as industrial design, furniture design and packaging design. In addition, even though the mainstream economy and sustainable economy are different most of the Thai lecturers gave little consideration to the economic aspect of sustainability. This issue was noted by a lecturer in the expert group (UNI-1-2) and confirmed through the interviews with 18 lecturers in the rest of the three groups (more details about the classification of lecturers are provided in Section 4.4.1). The 18 lecturers revealed that they taught the concepts related to sustainable design in classes. Some examples of learning content were provided in the interview sessions but none of them related to the economic aspect.

The findings from interviews indicate that active learning activities were mainly employed in the studio-based modules. A few examples were drawn from the interviews with industrial/product design lecturers as illustrated in Table 35.

Table 35: Examples of the use of active learning in studio-based modules in Thai industrial/product design education

Lecturer codes	The use of active learning in studio-based modules
UNI-5-1	Industrial design students were assigned to work with the real businesses in the industry to design products from waste materials. A lecturer played a role in consulting to help the design students to develop their designs.
UNI-1-2	A lecturer worked together with students as a design team to create and design sustainable products. An expert (UNI-1-2) mentioned the *"Lecturer should act as colleague not the expert who knows everything and takes over the whole class".*

The interviews show that studio-type class is acknowledged as a more effective way in the field of industrial/product design as it complies with the learning culture of designers.

4.2.3 Setting learning outcomes for ESD in Thai higher education

As presented in Chapter 2, setting learning outcomes is required to achieve ESD as it provides a framework that can guide lecturers to select teaching strategies and appropriate content (UNESCO, 2007). The interviews also discovered that lecturers were required to set the learning outcomes due to the implementation of the TQF. This section gives an overview of the TQF and its implementation in Thai industrial/product design education.

The TQF aims to assess and control the quality of Thai HEIs. Quality assurance is becoming more important for Thai education because of the dramatic rise in the number of HEIs, from 60 in 1999 to 171 in 2012 due to the drive from the government (Sandmaung and Khang, 2013) and demand from the society. More Thai residents have shown an intention to acquire a higher level of education as it allows them to earn higher incomes (World Bank, 2009). According to the salary survey of the federation of Thai industries (2011) the average salary of individuals with Bachelor degrees was 12303 THB while with lower degrees it was 8004 THB or 6953 THB. Table 36 presents the dramatic increase in the number of students enrolled in bachelor's degrees between 1998 and 2005. The number increased from 915,394 in 1998 to 1,656,427 in 2005.

Table 36: Higher Education Enrolment (OHEC, 2008 cited by the World Bank, 2009)

	1998				2005			
Institution	Total	Lower than Bachelor	Bachelor	Higher than Bachelor	Total	Lower than Bachelor	Bachelor	Higher than Bachelor
Public institution	808,209	9,812	743,428	63,969	1,645,840	71,414	1,418,029	156,397
Selective Admission	244,602	3,075	183,806	57,721	999,455	58,049	828,507	112,899
Open University	549,711	6,737	538,990	3,984	602,582	-	565,233	37,349
Autonomous University	13,896	-	11,632	2,264	30,438	-	24,289	6,149
Community College	-	-	-	-	13,365	13,365	-	-
Private Institution	188,087	-	180,966	7,121	254,363	-	238,398	15,965
Total enrolment	996,296	9,812	915,394	71,090	1,900,203	71,414	1656427	172,362

Although the rise of new HEIs has provided better education opportunities to the Thai residents, it has also resulted in lower quality of the HEIs. Siriporn (2011) states that education in Thailand is becoming more business controlled. There is more competition among both private and public institutions and many view achieving a degree as like selling products. Customers (students) receive their goods (degrees) if they complete the full payment.

This situation prompted the OHEC to develop and integrate the TQF. The integration of the framework was initially started in four disciplines: tourism, logistics, nursing and information technology in 2009. It was then expanded to other areas including industrial/product design courses in 2012 (OHEC, 2014). TQF is widely adopted as all HEIs have been tasked to do so (Laungaramsri and Siriphon, 2011). The framework assesses the Thai curriculum through the student learning outcomes that are divided into 5 learning domains as described in Table 37.

Table 37: TQF Domains of learning retrieved from OHEC (2006)

Domains of learning	Descriptive
Ethical and Moral development	Development of: -Habits of acting ethically and responsibly in personal and public life in ways that are consistent with high moral standards. -Ability to resolve value conflicts through application of a consistent system of values.
Knowledge	The ability to understand, recall and present information including: -Knowledge of specific facts, -Knowledge of concepts, principles and theories and -Knowledge of procedures.
Cognitive skill	The ability to: -Apply knowledge and understanding of concepts, principles, theories and procedures when asked to do so; and -Analyse situations and apply conceptual understanding of principles and theories in critical thinking and creative problem solving when faced with unanticipated new situations.
Interpersonal skill and responsibility	The ability to: -Apply knowledge and understanding of concepts, principles, theories and procedures when asked to do so; and -Analyse situations and apply conceptual understanding of principles and theories in critical thinking and creative problem solving when faced with unanticipated new situations.
Analytical and communication	The ability to: -Use basic mathematical and statistical techniques, -Communicate effectively in oral and written form, and -Use information and communications technology.
Psychomotor skill (if any)	Psychomotor skill domain is required in learning disciplines that highly develop physical skills, such as dance, music, and painting.

The processes of curricula assessment is divided into 7 steps; each step requires different cooperators and different roles. 7 TQF forms are required to be completed in the assessment processes as shown in Figure 22.

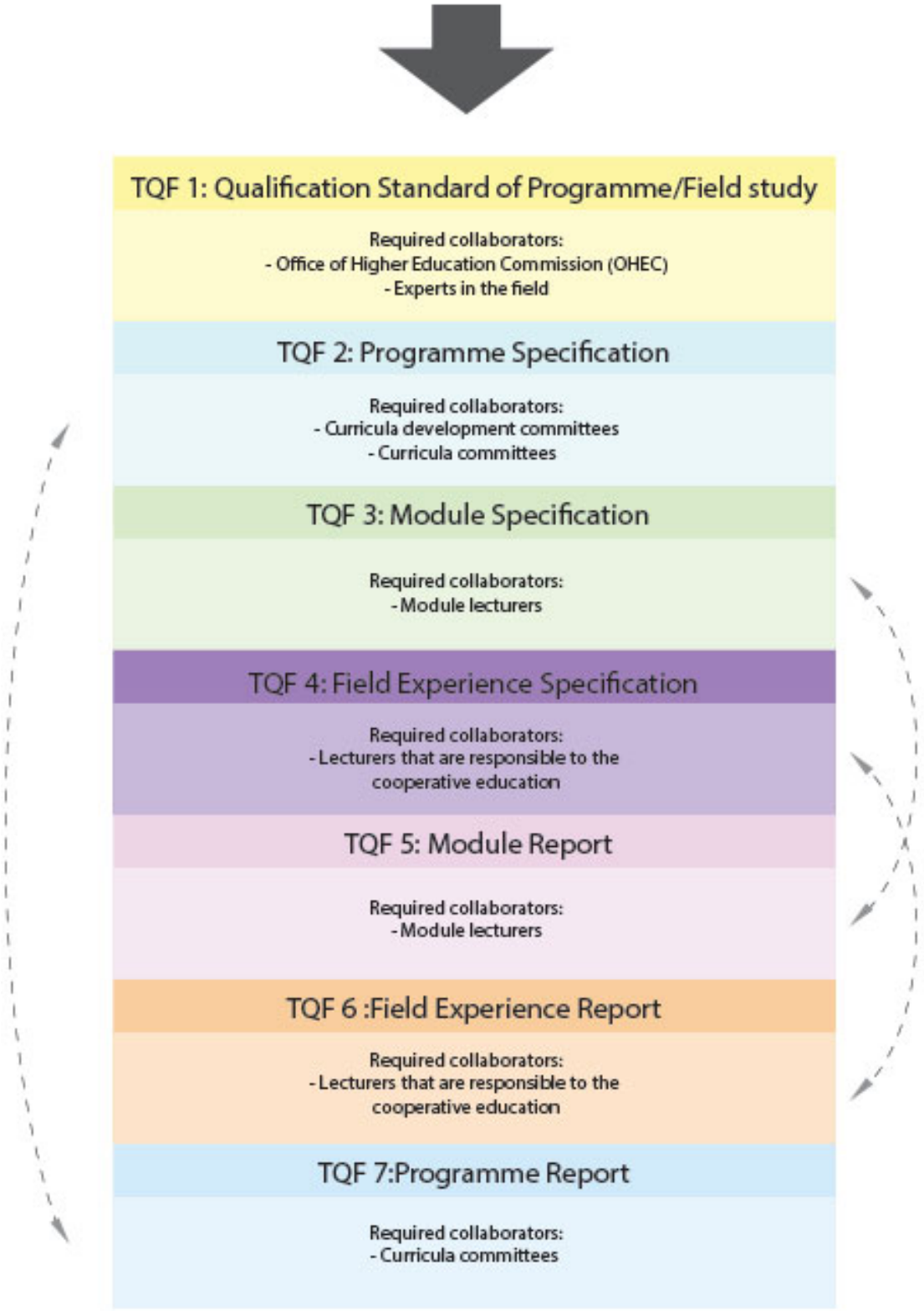


Figure 22: The assessment processes of TQF adapted from Nilsook, (2014)

The findings from interviews indicate that all industrial/product design lecturers need to be involved in at least 2 steps of the processes presented in Figure 22. Firstly, TQF 3 (module specification) can be considered as a teaching preparation process because lecturers are required to describe all details of the modules including general information, goals and objectives, module management, development of students' learning outcomes, teaching and evaluation plans and teaching materials (an example of the completed form is provided in Appendix C). Secondly, TQF 5 (module report) needs to be completed at the end of modules, and the results of the learning and teaching in the modules needs to be reported.

The TQF could be considered as an appropriate tool for ESD as it promotes a transformative approach as discussed in Section 2.3.4. As seen in Table 37, the five learning domains of TQF are quite similar to the set of competencies presented in Section 2.4. Along with its main goal (of assessing the quality of Thai undergraduate courses), TQF 3 and TQF 5 also enable lecturers to enhance their ESD teaching activities through self-reflection.

However, the interviews found that it was not able to fully support the integration of ESD in Thai industrial/product design courses. Firstly, there was no guarantee that the TQF would be employed in all ESD learning. Although all lecturers are required to adopt the TQF in their modules, the findings from interviews indicated that sustainable design was frequently taught through other design modules and often considered as an optional topic. The interviews also found that most of the lecturers that were responsible for modules did not consider ESD while developing the module specifications (TQF 3) and identifying learning outcomes. The curricula review also indicated the lack of sustainable design modules; with specific modules only available in 6 industrial/product design courses.

Secondly, the TQF was unproductively used in Thai industrial/product design courses. The interviews found that some lecturers only completed the forms but did not utilise them when planning their teaching activities. The TQF was developed based on the field of education but most of the design lecturers had a degree in design. Although professional development training enables current lecturers to

update their curriculum knowledge and pedagogical skills, the interviews indicated the lack of appropriate training for lecturers. Lastly, the TQF is in text format and cannot comply with the need of lecturers. Laungaramsri and Siriphon (2011) discovered that the assessment framework could not satisfy the needs of all lecturers; over 700 did not agree with the implementation of the TQF because it requires lot of form filling and increased workload. Section 2.6.1 discusses how designers prefer to receive information from creative resources that maximise the use of graphics and/or interaction.

4.3 Thai Industrial/Product Design Lectures

The findings from the in-depth interviews with participants in the lecturer group, and government agencies demonstrated the lack of government drive to implement ESD into Thai HE. Government initiatives focused on the business sector and gave less consideration to HE. Moreover, the interviews with experts in the Thai manufacturing industry identified that some participants (Thai companies) did not expect any capability in sustainability from young designers because they believed that the skills could be learnt from working experience.

As a result, Thai lecturers are the key influencers to incorporate sustainable design into product design education because they play a crucial role in constructing modules and are able to select the learning content. They are considered as being the key group that could influence the learning and teaching of sustainable design. In-depth interviews were employed to explore their attitudes.

According to UNESCO (2011), both pre-service and in-service lecturer training is required. The former is offered for students in undergraduate teacher training courses (Pavlova, 2008). The latter enables current lecturers to update their curriculum knowledge and pedagogical skills and is part of professional development (UNESCO, 2011). The investigation was narrowed down to in-service lecturers because the composite findings from the interviews and literature review indicated that the majority had degrees in design, with only a small proportion obtaining teaching-related degrees. This is because relatively few HEIs offered specific courses

for product design lecturers. Moreover, the interviews also indicate the lack of lecturer training related to ESD in Thai industrial/product design courses.

4.3.1 The classification of lecturers' knowledge in sustainability

The participants in the lecturer group were asked a set of questions relating to sustainable design (shown in Appendix G) to gauge their knowledge level. The results were then used to facilitate the data analysis and identify the target users of a new framework. The participants were classified on five levels based on their sustainable design knowledge as shown in Table 38.

Table 38: Classification of sustainable design knowledge of participants in the lecturer group

Levels	Novice	Advanced beginner	Competent	Proficient	Expert
Participant code	UNI-1-5-N UNI-2-3-N UNI-3-1-N UNI-4-1-N UNI-6-2-N UNI-7-1-N UNI-8-1-N	UNI-1-4-A UNI-2-2-A UNI-9-1-A	UNI-1-1-C UNI-3-3-C	UNI-1-3-P UNI-1-6-P UNI-1-7-P UNI-5-1-P	UNI-1-2-E UNI-2-1-E UNI-3-2-E
Number of participants	7	3	2	4	3

Participant codes provided in Table 38 initially consisted of letters and two numbers. The set of letters (UNI) refers to participants that were in the industrial/product design lecturer group. The first and second numbers represents HEIs and lecturers respectively. A letter at the end of each code was added later and refers to levels of lecturer knowledge (e.g. UNI-1-5-N is in the novice group). The knowledge acquisition model introduced by Dreyfus (2004) was employed to classify the lecturers because it is compatible with the field of industrial/product design. The

Dreyfus model not only uses knowledge as a factor to divide the levels of capability like other models, but it also considers skills that are associated with the learning culture of designers (Dorst and Reymen, 2004). Five knowledge levels of the model are shown in Table 39.

Table 39 Summary of skill acquisition model (summarised from Dreyfus and Dreyfus (2004))

Level 1: Novice	- is able to understand new knowledge that is composed in context-free features - is able to follow given rules - has little situation perception
Level 2: Advance beginner	- is quite similar to the novice level but has gained more experience - treats all aspects separately and give equal importance
Level 3: Competent	- has a broader view than the first two levels - is capable of determining priorities - sticks to the rules
Level 4: Proficient	- see a situation in a holistic view rather than as separated aspects - immediately responds and provides the right decision to address the issues
Level 5: Expert	- is immersed in the concept of sustainability - no longer relies on rules

Novice-Participants at this level have an understanding of some elements of sustainable design (e.g. 3Rs) and can perceive a new principle when it is set in context-free features. Some lecturers in the proficient and expert levels also agreed and mentioned that instructing on the topic of sustainability by focusing on one specific principle was more understandable. In addition, all participants in this group felt more familiar with eco-design than sustainable design and had more confidence discussing this topic. It was noted in the findings that they only had a little experience in integrating sustainable design and lacked in-depth knowledge.

Advanced beginner- their sustainable design knowledge is the same as the novice group, but they have undertaken more sustainable design projects. During the interview sessions, the lecturers requested the answers to questions that they could not answer and were able to immediately understand the new sustainable design information that was presented individually. However, they still do not have the confidence to decide which sustainability issue is most important and treat them all equally.

Competent- According to Dreyfus and Dreyfus (2004) the participants might feel overwhelmed and find it nerve-racking as they realise the difficulty to master the topic (or skills). This situation also happened to the participants; they did not feel confident in their sustainable design knowledge. However, the findings demonstrated that the product design lecturers in this level had gained enough experience in integrating sustainable design. The interviews found that all participants were aware of the product life cycle and had a broader view. They could determine the sustainability priorities and deliberately deal with various issues. However, they still relied on the fixed rule and theories that might not be appropriate in some situations.

Proficient - the interviews showed that the participants who achieved this level have obtained most of the basic principles of sustainability. Their collective understanding then enabled them to see the holistic view of sustainability. They instantly connected new situations with their previous experience and immediately identified the right solution to address unsustainable issues.

Expert- the interviews showed that only a few participants were categorised in this group. The experts immediately and intuitively replied to the questions as they were immersed in the concept and applied it into their daily life. They also gave some design case studies to elaborate their answers. The given cases were clearly explained and considered all three aspects of sustainability. Their decisions did not rely on uncertain rules as they had gained enough accumulated experience that could be used to analyse problems and identify the appropriate solution to reduce them.

4.4 Barriers to implementing ESD into the Thai higher education system

The literature review indicated the need to integrate ESD into Thai product design courses because it was widely acknowledged that product designers were in a position to influence eco- or sustainable design. The findings from interviews indicated that most participants in the lecturer group (details provided in Chapter 3) agreed with the literature and were willing to teach sustainable design. Most of the participants had already included some sustainable design or eco-design content in their classes. The concept of the 3Rs was the design strategy that frequently appeared in the interviews as examples of the teaching content. However, the interviews identified that they only dedicated a short period of time to teaching sustainability-related topics (typically less than 15 percent of the modules); owing to the barriers to implementing ESD in Thai industrial/product design education discussed in the following section. These barriers are divided into two sub-sections: the root cause of the common and specific barriers.

4.4.1 The root cause of the barriers to implement ESD into the Thai higher education system

Section 2.3.5 identified the five common barriers that obstruct sustainable design learning and teaching in the HE system as being: perceived irrelevance by academic staff, lack of staff awareness and expertise, crowded curricula, lack of institutional drive and commitment, and the complexity of social sustainability. The findings from the empirical studies also concurred with the literature review and confirmed these as common barriers in Thai industrial/product design courses. The empirical study identified that the root causes of these common barriers were (1) sustainable design was considered a lower priority than other subjects (e.g. manufacturing processes, aesthetic, and functionality of products) and (2) the lack of insight into sustainable design.

The participants in the lecturers' groups were classified into five groups based on the levels of sustainable design knowledge as presented in Section 4.4. The participants in all levels were aware of both the concept of sustainable design and eco-design as they were recruited through snowball sampling (Section 3.6); all participants were interested in design concepts related to sustainability. The lecturers in the expert

level also revealed that most Thai lecturers should have heard of concepts related to sustainability (OTOP and eco-design) as they have been extensively promoted through many channels including academic journals, mass media and academic conferences. Although all participants in the lecturer group expressed an interest in sustainability (or eco-design), 12 out of 19 only considered these concepts as current market trends rather that design criteria. One of the participants in the novice level said "*I have dedicated one or two sessions in my modules to discuss eco-design topics as it is the current trend in the product industry*" (UNI-7-1-N). This led them to overlook the concepts and cause the lack of understanding on sustainable design. The interviews showed that many participants could not clearly explain the principle of sustainable design (TBLs) or eco-design (product life-cycle). As illustrated in Table 38, 10 out of 19 participants from the lecturer group were categorised in the levels of novice and advanced beginner. All the expert level lecturers also revealed that Thai product design education was experiencing a shortage of lecturers with qualifications in sustainable design. The bullet points below show how the lack of knowledge and priority obstruct the implementation of ESD.

- Perceived irrelevance: some learning content can be easily linked with the concept of sustainability but most of the participants in the novice and advanced beginning levels could not see the links between them.
- Lack of institutional drive and commitment: some participants in the lecturer group also play a role in managing the courses. They can create the institutional drive through launching related policies but most of them only consider the concept as a marketing trend.
- Crowded curricula: the findings from interviews were that many design modules (studio-based) in Thai product design courses were flexible enough to integrate content relating to sustainability. However, many lecturers did not dedicate enough time for teaching sustainable design as they place sustainability concepts in the lower priority than others, such as manufacturing processes, aesthetics, and user-centred design.

4.4.2 Specific barriers that emerged in the Thai industrial/product design courses

Along with the five common barriers, the empirical study also identified other obstacles to implementing ESD in Thai design education. They are unveiled in this section.

4.4.2.1 Lack of consideration of TBL

As discussed in Section 2.8, a lack of consideration of the full spectrum of sustainability (economic, environment and society) has caused the unsuccessful implementation of sustainable design in the Thai manufacturing industry. Existing products focused on one or two aspects; OTOP products focused on social sustainability and eco-products focused on environmental sustainability. This situation also takes place in Thai design education where most of the related modules frequently stress one or two aspects. Although specific modules (directly related to sustainable design) enable students to draw all of aspects together, the findings presented in Section 4.2.3 indicated the lack of sustainable design modules in Thai industrial/product design education. The interviews revealed that some leading design institutions in Thailand tended to offer more sustainable design modules but many were unable to introduce a specialist module owing to the shortage of lecturers with sustainable development qualifications.

4.4.2.2 Students' backgrounds

Ten out of nineteen participants in the lecturer group identified students' background as one of the main obstacles to learning and teaching sustainable design. Experts (UNI-1-2-E, UNI-2-1-E) revealed that most of the students had already been taught to believe and rely on some concepts that contradict sustainability. Firstly, many undergraduate design students habitually gave priority to economic issues and as such did not balance the three aspects of the TBL. They made all decisions based on economic reasons and gave less consideration to the other two aspects. This was because they were influenced by their social environment which stresses economic aspects too much (UNI-1-6-P, UNI2-1-E). For example, some large companies have carried out some corporate social responsibility (CSR) activities that aim to return something back to society. However, the rationale behind these initiatives was only to advertise the companies'

credentials (UNI-1-2-E). The education sector was also responsible for this situation. Participants believed that the traditional education system was heavily biased towards the economic aspect as it encouraged students to consume rather than conserve.

As mentioned in Section 2.6.3, sustainable design had a lower priority than other design subjects in the design courses. Thai product design courses in each institution had different identities and strengths. For example, product design learning in KMITL focused on function and manufacturing processes while SU gave priority to aesthetics (UNI-2-1-E). These specific characteristics were also adopted by design students and were placed as a higher priority than sustainable design. For example, a participant (UNI-2-2-A) revealed that many of the student designs required production processes that would have a negative impact on the environment because they had prioritised appearance over sustainability.

Students have gained some unclear sustainable design information from mass media such as newspapers, design magazines, and TV programmes. An expert (UNI-1-2-E) revealed that the Thai media usually promote sustainable design through the 3Rs (reduce, reuse, and recycle) strategy, which is the first thing that comes to mind when discussing sustainable design. This can raise awareness but it has built the wrong mindset among students and also lecturers, as content related to the 3Rs strategy frequently appeared in the interviews with lecturers of the novice and advanced beginner groups.

> *"Eco-design is about reduce, reuse, and recycle material…"* (UNI-1-5-N).
>
> *"Eco-design or green design is the design that give less negative impact to the nature. It is 3R; reduce, reuse, and recycle"* (UNI-2-2-A)
>
> *"I have encouraged students to use eco-materials...reuse and recycle materials"* (UNI-6-1-N)

4.4.2.3 Lack of appropriate materials

The interviews indicated that lecturers in the novice and advanced beginner levels had the potential to develop themselves. Many had obtained some principles of sustainable design and already experienced eco-design or OTOP design projects. However, they could not describe the relationship between the TBL and were not aware of some key principles of sustainable design. Previous research projects (e.g. Victoria-Uribe, 2008; Cru and Diehl, 2006; Lofthouse,2006) proposed to address the lack of sustainable design knowledge through the development of learning materials. Thus, some ESD materials were available but the interviews with the design lecturers illustrated that none of them were compatible with the Thai industrial/product design courses. According to the experts (UNI-1-6-P, UNI-2-1-E), this is because most of the learning resources and tools that are presented in the Thai language were developed based on an engineering perspective that is too complicated for designers. Many western materials were specifically developed for industrial/product designers, however, they are still not able to be adopted into Thai design education owing to the language barrier and the difference in contexts. As previously mentioned, Wiriyachitra, (2002) found that the English proficiency of Thai citizens is relatively low in comparison to other countries in Asia. However, Thai nationals have been encouraged to improve their English as it has been selected as the language for business among ASEAN member states (Kirkpatrick, 2010). Although most of the participants revealed that they can acquire sustainable design information through English materials, they still preferred to utilise materials that are presented in Thai as it is their first language. In addition, all participants revealed that they were not aware of any materials that were specific to them. Moreover, the findings from interviews concurred with Section 2.8.4 that the implementation of TQF had not been not successful. The interviews found that many design lecturers only completed the forms but did not utilise the benefit in planning their teaching activities. The interviews also identified three main obstacles to fully implementing TQF in Thai design education: (1) it is difficult to understand and apply, (2) it cannot comply with the learning culture of design lecturers, and (3) it is time-consuming.

4.4.2.4 Lecturers' mindset

According to the findings from interviews, most of the participants (lecturers) mentioned that they were willing to teach sustainable design. Some of them had already taught it in their classes. However, the interviews found that many considered issues related to sustainability to be a lower priority than other topics such as business, aesthetics, and function. For example, a participant mentioned that "…should enable students to acquire skills in design before starting to teach sustainable design" *(UNI-2-3N).*

Moreover, Section 2.6.2 presents that involving active learning activities in lecture-based classes enable lecturers to enhance students' retention rate. However, the interviews found that some participants in the lecturer group still employed teaching strategies were based on the traditional approach and resisted the applications of a new approach because they believed that it was not appropriate to some design students. Participants (UNI-1-4-N, UNI-7-1-N) revealed that they had encouraged students to participate in active learning activities. Design students were assigned to carry out some research to discuss in the classes. But they did not fully contribute to the classes; some students did not complete the tasks, and some were not confident to show their opinions.

4.4.2.5 Ineffective planning for the learning and teaching of sustainable design

The findings from interviews showed that participants in the lecturers' group had already applied teaching strategies that rely on the transformative approach. The findings show that active learning strategies were utilised as they are partly associated with the nature of industrial/product design courses that emphasise the need for practicing design. In other words, these courses have already engaged students through two domains: cognitive (Section 2.2.3.1) and psychomotor (Section 2.2.3.3). However, they cannot effectively utilise the strategies to teach sustainable design because of the lack of priority and inappropriate use of learning outcomes. Firstly, sustainable design was considered a lower priority as it was usually taught through other and/or related modules (Section 4.4.1). Section 4.2.3 also indicates that specific modules for sustainable design were only provided in 6 industrial/product design courses. The findings from interviews also showed that

ESD outcomes (competencies) were not included in the plan of modules that taught sustainability. Chapter 2 suggests that setting learning outcomes is required to achieve ESD as it guides lecturers to select teaching strategies and enhance teaching capability.

Secondly, the interviews found that Thai design lecturers were required to identify the learning outcomes. Some outcomes (or competencies) were related to ESD but they were not properly used. An expert (UNI-3-2E) mentioned that some lecturers only copy learning outcomes from others and complete the TQF form; they do not utilise its benefit in planning their modules.

The root cause of the ineffective teaching activities is that Thai industrial/product design lecturers do not have an insight into ESD. The interviews found that 16 out of 19 participants had a degree in design and were not aware of an ESD teaching approach. They intuitively taught sustainable design based on their accumulated teaching experience. Although UNESCO has emphasised the need for enhancing teaching capability of in-service lecturers to achieve ESD (Sleurs, 2008), the interviews indicated a lack of professional development training in Thai industrial/product design education.

4.5 Conclusion

Findings from the interviews indicated that lecturers were key change agents to integrate ESD into Thai product design education due to the lack of drive from the government and business sectors. Some sustainable design modules will be introduced due to the calls from lecturers (see Section 4.2.3). Moreover, Chapter 2 indicates that lecturers are playing a role in selecting learning content. The findings from interviews show that most of the participants have allocated some time to teaching/discussing sustainability in their classes.

Section 4.2 provides the overview of ESD implementation in Thai industrial/product design education. It discusses how sustainability is taught through both general education and specialised modules. The findings found that specialised modules were more appropriate to design students as they involve some active learning activities that comply with the learning culture of designers and ESD. Although the

interviews show that general education modules (traditional lectures) do not effectively provide information for design students, they were still required for Thai industrial/product design courses due to the limit of time and human resources. In addition, the findings show that some groups of students preferred and were familiar with traditional lectures. The findings presented in Section 4.2 support the findings from the literature review (2.6.2.3) that teaching strategies can be selected based on the context: student background, learning culture, and resources provided. Lecturers are then required to play a crucial role in constructing the modules and selecting the teaching strategies that are appropriate to the context. Chapter 2 presents that education reorientation is required to achieve ESD; lecturers have been encouraged to shift their focus from input (learning content) to output (learning outcome). Section 2.3.5 discusses how setting learning outcomes can guide lecturers to select learning strategies and assess their teaching performance. The findings from interviews discuss the use of appropriate approaches for ESD in Thai design education. Section 4.2.3 found that lecturers were required to adopt the TQF as a support tool for ESD because it relies on the output approach. However, Section 4.2.3 found that the TQF could not effectively contribute to the ESD implementation because (1) it was not utilised in all ESD learning, (2) it was unproductively employed, and (3) it could not comply with the need of design lecturers.

Although the findings presented in Section 4.4.1 show that the lecturers were willing to teach sustainable design, they considered it as a lower priority than other topics such as business, function and emotional design. Moreover, the findings from the interviews also show that most of the participants could not clearly explain the principle of sustainable design and the relationships between the TBL. Section 4.3.1 indicates that many lecturers have the potential to shift from novice or advanced beginner levels to competent or higher levels. However, they were hindered by the lack of appropriate materials and professional training to enable them to enhance their pedagogy skills and qualifications in sustainability. To sum up, the findings presented in Chapter 4 suggested that the new material should enable lecturers to identify ESD learning outcomes in their modules and systematically plan their

teaching activities. The findings were also utilised as a basis to identify the requirements for the framework development that is discussed in Chapter 5.

Chapter 5: Development of the Knowledge Framework Dissemination

5.1 Introduction

Chapter 4 identified why Thai industrial/product design lecturers cannot effectively teach sustainable design owing to the lack of an appropriate teaching plan and insight into sustainable design. As presented in Chapter 2, ESD aims to reorient educational systems (both method and content) to be more appropriate for sustainable design. Although materials have been developed to enable lecturers to implement ESD, they cannot be adopted and successfully used in Thai HE due to the difference in context as discussed in Section 2.8. The PhD thesis then proposes to overcome the barriers and contribute to ESD implementation in Thai industrial/product design through the development of a new framework that will enable design lecturers to properly plan and selected appropriate learning strategies (methods). Moreover, a web-based tool called "*SustainAble*" is also introduced to support the developed framework. The web-tool is interactive and uses graphics so is designed to complement the learning culture of a design lecturer. It also offers a set of information that allows Thai lecturers to gain a better understanding of sustainable design and be more effective in using the framework.

Chapter 5 presents the development of the framework in 6 sections: identifying main target users (Section 5.2), identifying the criteria to develop the framework and the web-based tool (Section 5.3), framework development (Section 5.4), distribution of the developed framework (Section 5.5), *SustainAble* web-based tool (Section 5.6), and Conclusions (Section 5.7).

5.2 Main target users

The identification of the main target users was required as it allows the new materials to precisely satisfy their needs. In Chapter 4, Thai lecturers were divided into four groups based on the Dreyfus's knowledge acquisition model (Dreyfus, 2004) and the findings obtained from interviews. The four groups of lecturers were: novice, advanced beginner, proficient, and expert. Novices and advanced beginners

were considered as the main target users of the framework due to the reasons discussed below:

The first reason was to satisfy the need to increase the number of lecturers with ESD qualifications. Sustainable design is complex and requires frequent practice and learning. However, Chapter 4 discovered that ESD represents only a small proportion of the overall product design curricula due to the lack of lecturers with a sustainability qualification. Increasing the number of lecturers is then required to achieve ESD integration as it enables students to have more opportunities to learn and practice more about the topic. Lecturers in the novice and advanced beginner group were selected because they constitute the majority of Thai product design lecturers in the sample (11 out of 19 respondents belonged to these two groups) and experts also revealed that the majority of Thai lecturers were novices or advanced beginners. Most of the participants in these two groups discussed sustainable design without consideration of the full spectrum of sustainability (or TBL), which is a required competence for the level of proficiency. In addition, the result was confirmed by the responses from participants in the expert group. Many Thai lecturers teach sustainable design or eco-design by focusing on a few particular issues rather than the whole system (UNI-2-1-E).

Secondly, a lack of understanding of sustainable design by lecturers obstructs ESD learning and teaching. For example, "*lecturers with a vague understanding of sustainability will give an unclear explanation to design students*" (UNI-3-3-C). As mentioned in Chapter 4, sustainable design was considered as one of the current marketing trends in the Thai product design industry. Thus, Thai lecturers have been influenced to discuss related topics in their classes. Proficient and expert lecturers were able to effectively deliver information to students as they have accumulated experience in sustainable design and properly planned the learning activities. However, many lecturers inappropriately transfer sustainability information and might obstruct the learning processes of students. An expert mentioned that "*many Thai lecturers do not notice that they are misunderstanding sustainable design and continue teaching the wrong information to students*" (UNI-3-2-E). The findings show that many Thai undergraduate students still preferred a lecture-centred approach; it

can be assumed that they accept and believe all statements that are delivered from their lecturers.

Lastly, the findings from the interviews showed that the target group has a high potential to be more knowledgeable in sustainable design and more competent to teach it as they had already gathered some sustainable design information and experience. Moreover, many of the target users had already started to employ appropriate strategies in their classes. However, they were obstructed in the development of their ESD capability due to a lack of appropriate resources (as discussed in Section 4.4.2.3).

5.3 Framework and its dissemination criteria

The findings obtained from the literature review and interviews were utilised to identify criteria for the development of an ESD learning framework for Thai product design education. The four criteria are outlined in the following sections.

5.3.1 System organisation of learning activities

Chapter 2 suggested that a set of appropriate learning strategies should cover all three of Bloom's domains to engage students through their head, heart and hands. This is because achieving ESD requires profound changes in knowledge, skills, and attitude. The educational reorientation has already been started in Thai product design education as evidenced by the publishing of academic papers in the product design field such as the use of community based learning and problem based learning (Boonla-ro and Chuenrudeemol, 2010). Moreover, Lehtonen (2010) demonstrated a successful result from applying Bloom's taxonomy for ESD in a Thai product design course. The findings from interviews with sustainable design lecturers also showed that they have employed sets of learning activities that cover the three domains.

Although the interviews demonstrated the use of appropriate strategies in Thai industrial/product design courses, they cannot fully support ESD learning due to the lack of proper teaching plans. Chapter 2 discussed how setting learning outcomes enable lecturers to systematically select teaching strategies and construct the modules. However, Chapter 4 discovered that many design lecturers only identify

the outcomes but do not utilise their benefits in selecting teaching strategies and planning.

This failure in teaching preparation is caused by a lack of appropriate training for in-service lecturers. Chapter 2 discussed how professional development is required as it allows lecturers to development their knowledge and pedagogic skills. However, all participants revealed that they were not aware of professional training that related to ESD. Consequently, the framework should address this shortfall and facilitate the target users to comprehensively identify appropriate learning outcomes and the strategies that enable students to achieve them.

5.3.2 Development of knowledge in sustainable design

The findings from interviews indicated that the target lecturers cannot effectively and appropriately integrate sustainable design (and/or eco-design) content into their lessons. Although the findings showed that some of the participants in the target audience groups had experienced some sustainable design projects, they were not able to clearly explain about the topic due to two reasons discussed below:

Firstly, the interviews indicated that most of the target lecturers were not aware of some sustainable design principles such as TBL, renewable materials, and avoiding hazardous substances. The findings also show that many the Thai lecturers only considered the 3Rs principle (reuse, recycle, and reduce) while they were conferring about sustainable design (or eco-design). Most respondents in the expert group agreed that the 3Rs principle was the first thing that came to many lecturers' minds because it had been widely promoted through the mass media. The principle of 3Rs frequently appeared in the interviews, with respondents in the novice and beginner groups. Moreover, they did not recognise the relationship between eco-design and sustainable design, and some of them thought that they were similar.

Secondly, most of the target users overlooked the holistic view of sustainable design. In the interview sessions, they only proposed to address a few particular sustainability issues rather than the whole system. They also discussed sustainable design without the consideration of the TBL and/or the key product life cycle principles.

To sum up, facilitating in-service lecturers to perceive the holistic view and develop their sustainable design knowledge is required to achieve the implementation of ESD in Thai industrial/product design education. Because, the misunderstanding of lecturers can obstruct the students' learning processes as discussed in Section 5.2.

5.3.3 Application within the Thai education system

Chapter 2 found a large amount of ESD materials are available online but most of them cannot be effectively adopted into Thai undergraduate industrial/product design courses owing to the difference in context. Moreover, most of the Thai lecturers do not have enough drive to integrate sustainable design. The interviews showed that many participants felt uncomfortable and avoided integrating ESD if it was time-consuming and/or complicated. The interviews revealed that all participants were willing to teach sustainable design but they would only dedicate limited time because they only considered it as the market trend rather than one of the design criteria. According to the literature review, institutional drivers can break the mindset of lecturers and influence them to implement ESD (Dawe, 2005). However, the findings outlined in Chapter 4 showed that Thai design courses did not emphasise ESD implementation. An expert (UNI-2-1-E) revealed that many undergraduate courses include promoting sustainable design in their course objectives but they only gave limited contribution in practice.

Consequently, the developed framework should be easy to understand and compact. It should be able to be directly applied to Thai industrial/product design courses without any significant changes in the current education system. The researcher then investigated the formats of learning and teaching of sustainable design that were used in Thailand for tailoring the framework to fit the Thai context. The literature review found that ESD has been integrated into the industrial/product design education in three different formats:

- Sustainable product design courses: the literature review showed that some HEIs in other countries have started to offer product design courses that specialise in sustainable product development. However, the reviews of Thai curricula (Section 2.8) discovered that there were no specific courses

available in Thai HE. The findings from the interviews also confirmed the result from the curricula review and found that the Thai institutions do not have intentions to introduce new sustainable product design courses in the near future.

- Individual sustainable design modules: as discussed in Section 4.2.3, the interviews showed that Thai product design courses have started to offer more individual sustainable design modules. But, these modules have only been introduced in a few of the HEIs due to the lack of drive and design lecturers with qualifications in sustainable design. All lecturers in the expert level discovered that the lack of lecturers with a sustainable design qualification was the main barrier to implementing ESD. According to the findings from the empirical study (Chapter 4), the participants that have taught the specific modules were in the proficient and expert groups so able to facilitate students to gain an understanding of sustainable design.
- Teaching in other modules: as presented in Section 4.2.3, the interviews found that sustainable design is not only taught in the specific modules (discussed in the previous paragraph). Learning and teaching of sustainable design can also be found in other design modules such as furniture design, packaging design and industrial design. This is because Thai lecturers have been influenced by the promotion of sustainable design in the business sector. One participant (UNI-7-1-N) revealed that "*it is required to discuss sustainable design or eco-design in classes as they are the current trend in the industry*".

This third format was taken into account because the interviews showed that most of the target lecturers regularly used this particular channel to teach sustainable design. Moreover, the intervention can rapidly happen through the third channel as it is fully led by lecturers. Drives from the government and education sectors are required to introduce a brand-new sustainable design module or a specific course but the findings from Chapter 2 and 4 concluded that the Thai government and business sectors have not given enough motivation to the ESD implementation.

5.3.4 Compliance with learning culture of designers

The findings from the literature review and interviews with participants from the government sector indicated that a number of eco-design resources were available to support Thai HE as the country has a strong tradition in EE. However, the interviews with product design lecturers found that most of them were obstructed in accessing information and still have an unclear understanding of eco-design because most of the resources had been developed based on engineering or science perspectives that did not comply with the learning culture of designers. Chapter 4 discussed how most of the in-service lecturers in Thai product design courses have a similar learning culture to designers as they have a background in design. This section presents two main reasons that caused the failure in delivering sustainable design information to designers.

- Primarily, inappropriate information: the interviews found that most Thai tools provide content related to engineering and science. Some of the information is not relevant to the design profession and can cause failure in knowledge transfer. An example was given by an expert (UNI-2-1-E), although designers are only required to possess life cycle thinking in general, some of the tools recommended users to intensively apply life cycle assessment which requires numeric skills to solve complex equations.
- Secondly, unsuitable presentation style: the literature review showed that designers prefer to acquire information that is creatively presented and offers brief descriptions. However, most of the Thai resources present eco-design information in text format which does not satisfy the more visual needs of designers. Consequently, the new framework was required to take into account the learning culture of design lecturers and present information in a style which was complementary to their teaching.

5.4 Framework development

The learning and teaching framework was developed based on the criteria outlined in Section 5.3. It aims to enable Thai product design lecturers to be more systematic in selecting and organising activities for ESD learning and teaching in their classes or modules. This framework consists of three sections: sustainable design

competencies (Section 5.4.1), triangular learning domains (Section 5.4.2), and two major learning types (Section 5.4.3).

5.4.1 Sustainable design competencies

As discussed in Section 2.3.4, a number of publications have encouraged lecturers to shift their focus from preparation of learning content (input) to determination of learning outcomes (output). This is because it seems impossible to identify learning content that can be used to address all sustainability issues, which are quite broad and can be changed based on uncontrollable factors such as economic crisis, climate change, and political issues. To summarise, the traditional approach provides students with a set of information to address problems, whereas the transformative approach equips students with the solution to deal with sustainability issues. Moreover, identifying the required competencies enables lecturers to increase teaching effectiveness. They can utilise the competencies as goals to accurately assess students' progress and measure effectiveness of learning activities. The framework development initially started from identifying appropriate competencies for Thai sustainable product designers. As discussed in Section 2.4, many researchers have attempted to determine competencies for sustainable development. The work of Wiek et al. (2011) was considered as the basis for the framework development. While others presented selected competencies in a list format, Wiek et al. (2011) introduced a set of five competencies in the format of a problem-solving framework (as seen in Figure 23) that is compatible with the type of visual information used in the product design profession. Most product designers are already familiar with the problem-solving format which is typically used to create new designs to address problems of existing products or introduce better life styles.

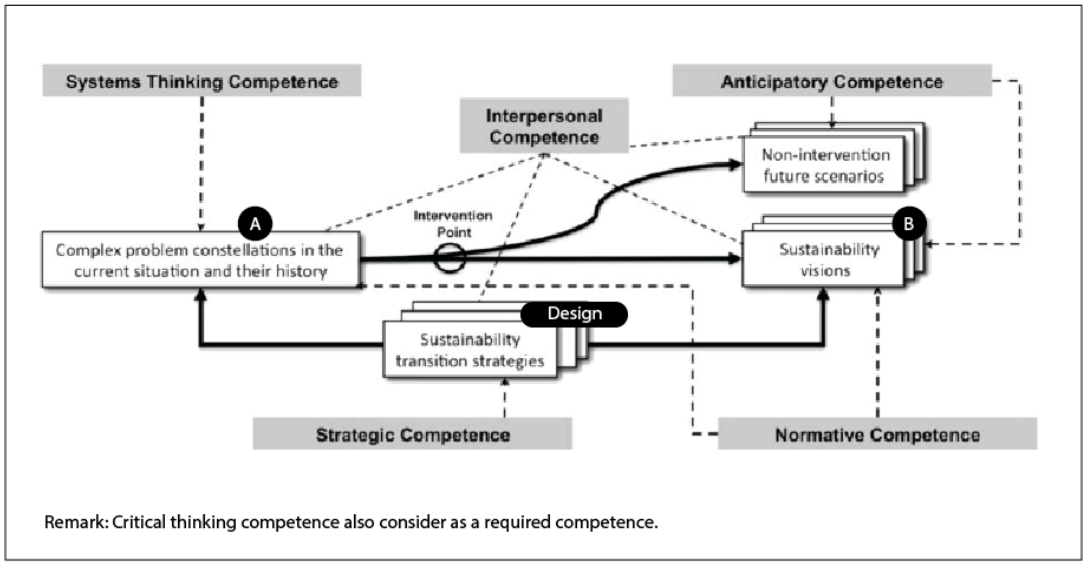


Figure 23: The set of competences for sustainable development (modified from Wiek et al., 2011)

The set of competencies is also associated with the logic that has widely been used to teach design students. According to Findeli (2001), most design schools rely on the logic that considers design as a link to transform state A (needs, problems) into state B (goals, solutions). As seen in Figure 23, state A and state B can be referred to as complex problems and sustainability visions respectively. Designers are required to understand the whole system of state A and develop sustainability transition strategies.

In addition, the selected set of competencies already complies with the needs of the Thai manufacturing industry. Although most of the participants in the group of design companies did not straightforwardly identify the required competence, two competencies in sustainable design were implied through their responses in the interview session.

- Normative competence: all the participants in the industrial expert group agreed that new designers cannot successfully integrate sustainability into product design as they do not adequately understand the concept. All the participants also underlined that most graduate designers do not have a clear understanding of concepts related to suitability. For example, *"most of the designers propose to design sustainable-products by focusing on a single issue rather than the whole life cycle"* (COM-4).

- Strategic competence: an industrial expert (COM-3) in local product development discovered that many Thai designers failed to integrate Thai craft skills into product design due to a lack of experience. They usually adopt Thai skills in product development without the consideration of target users. For instance, some designers employ Thai wickerwork techniques that are traditionally used to create fish traps (as shown in Figure 24) to design products. They usually create only decorative products as they keep using the same shape and a similar pattern. This limits their ability to create products in other categories that can generate more profit and have more demand in the international markets. Another design director mentioned that "*young designers cannot effectively apply eco-design as they lack opportunity to practice. There is only a limited number of companies that intend to develop real eco-products. Most companies only want to claim that their products are eco-friendly due to marketing reasons*" (COM-2).

Figure 24: A fish trap created using a Thai wickerwork technique

5.4.2 Triangle learning domains

As discussed in Section 2.3.3, the classification of learning outcomes enables lecturers to appropriately select teaching strategies and successfully facilitate their students to achieve the required outcomes. The literature review demonstrated that Bloom's taxonomy is a suitable principle to classify the learning outcomes for sustainable development. This is because ESD requires profound change in three different elements that can be engaged through three learning domains of the taxonomy: knowledge (cognitive domain), skills (psychomotor domain), and attitude (affective domain). However, the interviews showed that most of the Thai product design lecturers overlook these three learning domains. As a result, the domains are

included in the developed framework to remind the target users to utilise this principle. They are presented through a triangular model that consists of three parts; each part represents a learning domain as seen in Figure 25.

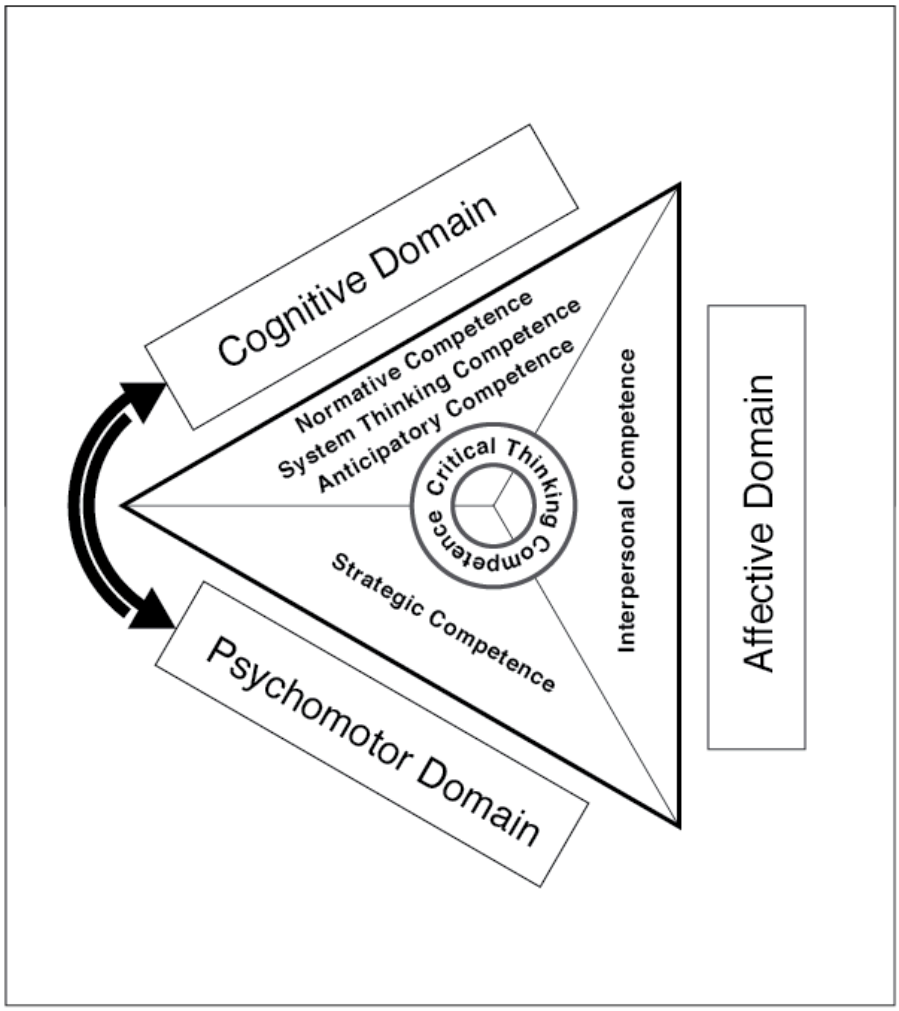


Figure 25: The combination of selected competences and three learning domains

Six required competencies, identified in Section 5.4.2, were divided into three groups and included in the triangle based on the domains that can be used to engage students in building these competencies as shown in Figure 25. Among the six competences, critical thinking was placed in the middle and covers all three learning domains as it is associated and is able to be influenced through all three (more details see Section 2.4.6).

In addition, the two-way arrows illustrate the connection between the cognitive (head) and psychomotor (hands) domains. The findings from the interviews

concluded that achieving competencies in either head or hand domains increases the potential to acquire competencies in another domain. All lecturers in the expert level agree that learning by doing (psychomotor domain) is important as it allows design students to gain a greater understanding of design principles. Starting from the cognitive domain, having insight into the basic principles allows students to be more effective in practicing design projects.

5.4.3 Two major learning types

Ramirez (2012) states that sustainable design is usually taught through lecture and studio based modules. The curricula reviews (Section 2.8) and interviews also showed similar results. The framework uses these two types as a foundation. However, according to the criteria outlined in Section 5.3.3, the framework was developed based on the characteristics of ESD learning in the third format: teaching through other design modules.

According to Figure 26 below, the combination of required competences and learning domains from the previous section was placed under two rectangles that represent the two learning types of Thai industrial/product design education. The rectangles are used to illustrate how the three learning domains are engaged through the two learning types. More details are provided in the following sections.

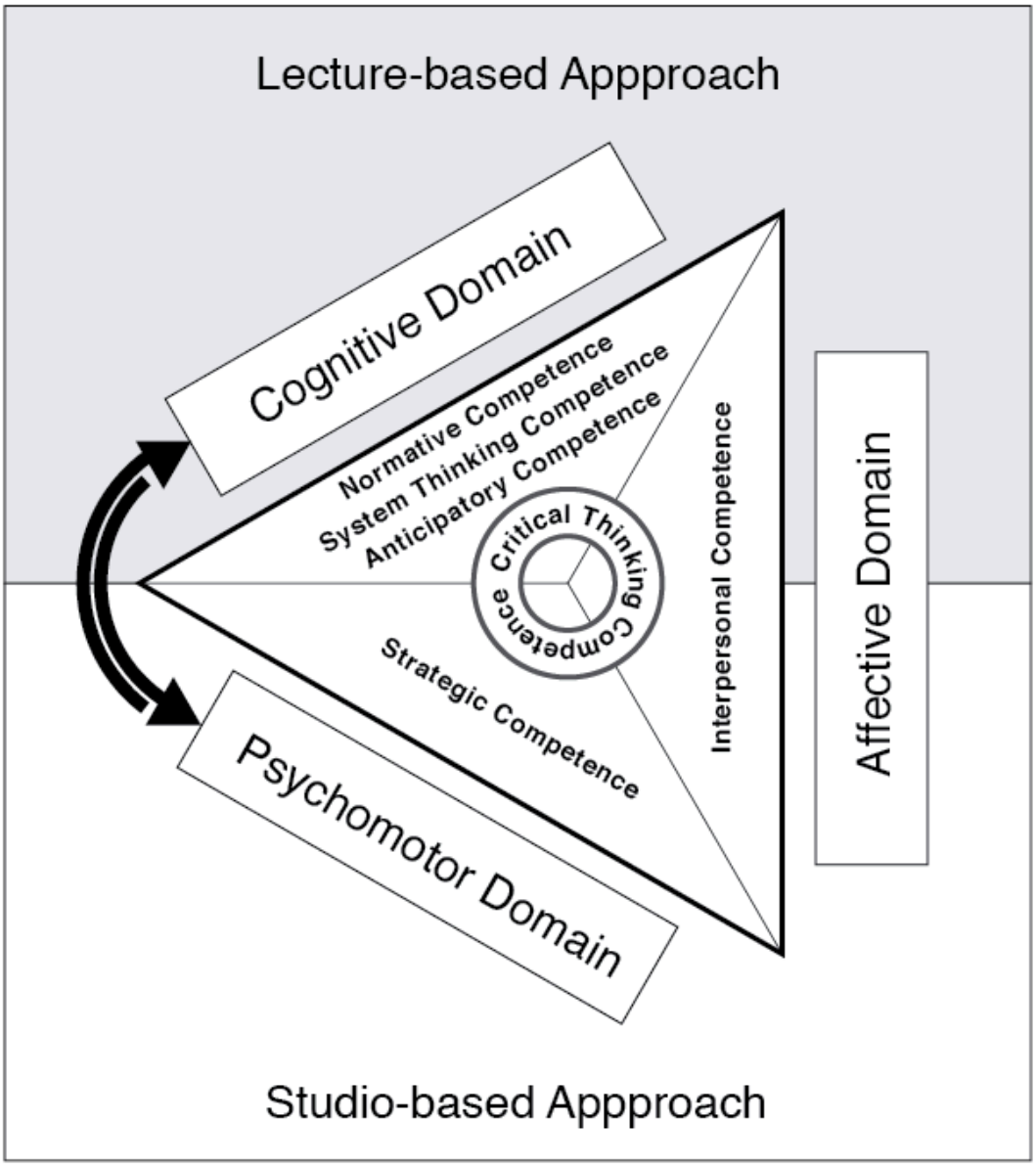


Figure 26: The ESD learning framework for Thai product design education

5.4.3.1 Lecture-based classes

Although the findings showed that most of the Thai industrial/product design students prefer to learn through studio-based classes, the lecture-based type is still emphasised and incorporated into the framework as it is required to achieve ESD. According to Ramirez (2011) lecture-based classes allow students to acquire the basic theories associated with sustainable design. The interviews showed that most of the target users rely on a lecture-centred approach and only emphasise the cognitive domain. Some of them feel that a student-centred approach is not appropriate for the Thai HE system due to a lack of student engagement. For

example, "*Thai students are not like western students. They are not keen to know; they will not carry out any research if you do not assign them to do*" (UNI-1-4-A).

However, the shift to the student centred is required as it can facilitate lecturers to engage students through the affective domain. This domain is needed for achieving ESD as it requires a profound change in behaviour (as discussed in Section 2.2.3.2). Moreover, the interviews with lecturers in the proficient and expert groups showed that engaging students through the affective domain can increase their interest in the topic and stimulate learning in the cognitive domain. For example, a lecturer in the expert group utilised a carbon foot-printing calculator to enable students to gain awareness of the amount of carbon that they have produced. After the activity, students felt guilty and then were keen to find ways to reduce their carbon footprint. Consequently, the lecture-based rectangle, shown in Figure 26, then covers cognitive and affective domains to encourage the users to utilise both in lecture-type classes. It also shows that the lecture classes can be employed to equip students with competencies in the two domains.

5.4.3.2 Studio-based classes

The findings from both Chapter 2 and Chapter 4 identified that design students prefer to learn through a studio-based approach as it complies with the learning culture of designers who already teach topics related to sustainable design and eco-design through studio classes.

Similar to lecture based approaches, the affective domain was also not the focus in this module type. The lecturers mainly engage student through the psychomotor domain that is directly related to the module. Design students are usually assigned to design and develop a product by considering sustainable design as one of the project criteria. The lecturers frequently overlooked the need to engage students through the affective domain that is required to achieve ESD. According to the interviews with 19 lecturers, all of them gave examples of teaching strategies that engage student through the psychomotor domain but none through the affective domain. It is then important to emphasise the affective domain which can encourage

students' willingness to embrace the concept. As seen in Figure 26, the affective domain was then also included in the studio based approach.

5.5 Dissemination of framework

According to Chapter 2 and Chapter 4, the internet is the most appropriate channel to promote the developed framework within Thai HE for two major reasons.

Firstly, a relatively low budget is required to develop a site, according to Section 4.2. Sustainable design is becoming more widespread in Thai HE but the findings indicated that few sustainable design activities have been carried out in industrial/product design courses due to the lack of drive and support. Most of the ESD active contributors are in the field of engineering, thus most of the existing initiatives were related to the field of engineering. Moreover, Section 4.1 also disclosed that the government has planned to focus more on the business sector and decrease the support provided to HE. An online channel was the most appropriate method to dispense the framework to the target users because it is a relatively low budget option and requires few contributors (e.g. a web developer and a sustainable design expert). In addition, sustainability issues are constantly changing due to changes in the context, thus the framework might be required to be frequently updated. A web-based format allows easy access to regularly update the information.

Secondly, a web-based format is compatible with the target users. Chapter 4 found that most of the in-service lecturers have a similar learning culture with practicing designers as they also have a background in design. The literature review identified that web-based tools can comply with the learning culture of designers as they allow the use of mixed media (videos, sounds, and images) that enable developers to creatively present information (more details are discussed in Section 5.6.1). Moreover, the interviews with the design lecturers showed that all of them have utilised the internet to acquire information for teaching preparation and self-development.

5.6 Web-based tool (*SustainAble*)

As established in the previous section, online communication is the most suitable solution to distribute the developed framework into Thai product design education. A web-based tool was then developed to disseminate the developed framework. Moreover, it also allows the framework to comply with the learning culture of designers who prefer to acquire information through creative media (as discussed in Section 2.5.2.1). It can be accessed at www.SustainAble.in.th. The web–tool enables the framework to be used in practice to support sustainable design teaching and learning because the framework itself cannot satisfy all the requirements listed in Section 5.3. Thus, another complementary element (Sustainable design information part) was included in the tool to satisfy other requirements and fulfil the new framework.

As illustrated in Figure 27, the homepage of the tool provides links to the instructions and two main streams. The target users can select either “How to teach” for access to the learning and teaching framework or “Sustainable design info” to access sustainable design information. These actions would direct users to one of the two pages illustrated in Figure 28.

Figure 27: The homepage of the *SustainAble* web-based tool

Figure 28: the first pages of "Sustainable design into" and "How to teach" parts

The section below discusses the *SustainAble* web-tool in more details through four sub sections including: Presentation style (Section 5.6.1), Sustainable design information part (Section 5.6.2), How to teach part (Section 5.6.3), and Sustainable design case studies part (Section 5.6.4).

5.6.1 Presentation style

To satisfy the requirements outlined in Section 5.3.4, the desirable characteristics provided in Section 2.5.3 were utilised to enable the web-based tool to successfully deliver the information to design lecturers. Firstly, as designers prefer to obtain a small amount of data, the tiered system in Figure 29 was then selected to organise all data in the *SustainAble* web-tool because it allowed the tool to keep information to a minimum.

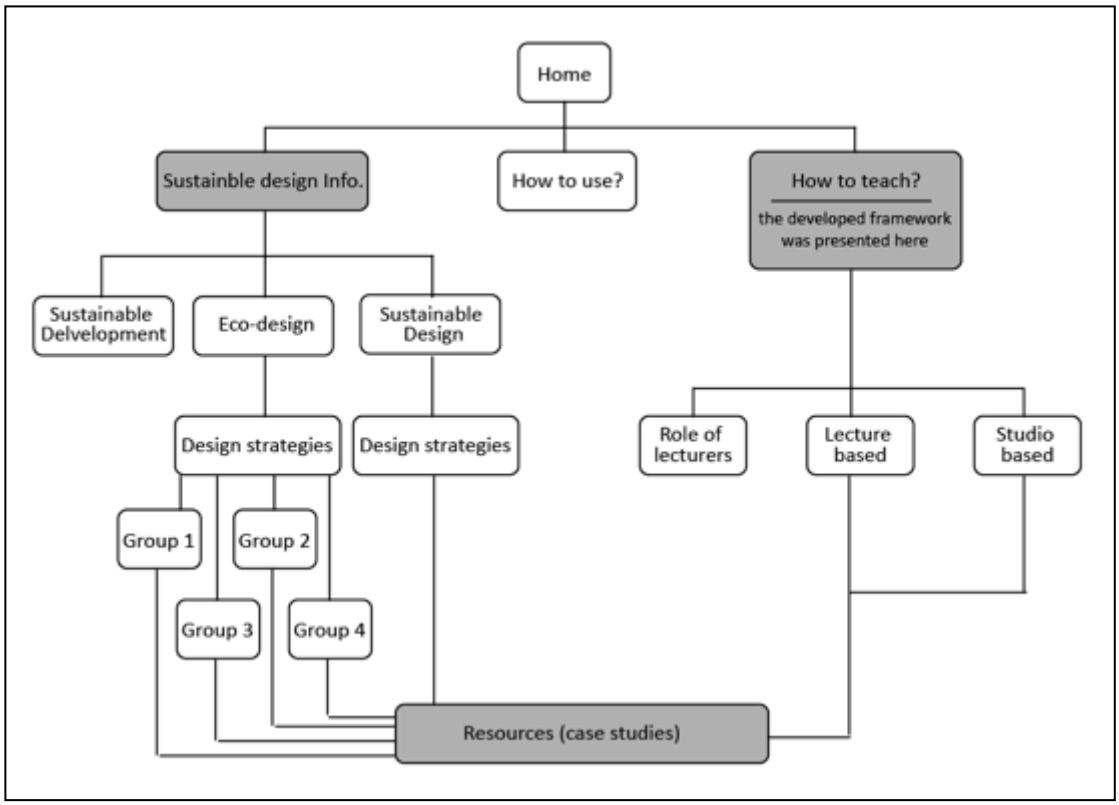


Figure 29: A sitemap of *SustainAble* web-tool

For example, the webpage in Figure 31 shows the relationship between sustainability concepts but it does not describe all of them in detail. The users can access more details by clicking links in the visual menu. Moreover, the full use of graphics also allows the tool to deliver information with the minimum use of text. Pictures and diagrams are then utilised to explain the information provided. For example, the diagram in Figure 33 is used to simplify the concept of product life cycle. Furthermore, interaction can encourage the attention of the target users, the various hyperlinks and visual menus can then be used to enable the users to access the webpages in the web tool. Design case studies and some information are presented through video clips or motion graphics as shown in Figure 30.

Figure 30: A snapshot from a video created by the story of stuff project (Thai subtitle is also available) (www.storyofstuff.org).

In addition, Figure 31 shows the shortcuts that are provided to navigate users to the first webpage of each section because the information is divided into small content and presented in a number of webpages. These shortcuts provide users with a more convenient way to search for information required.

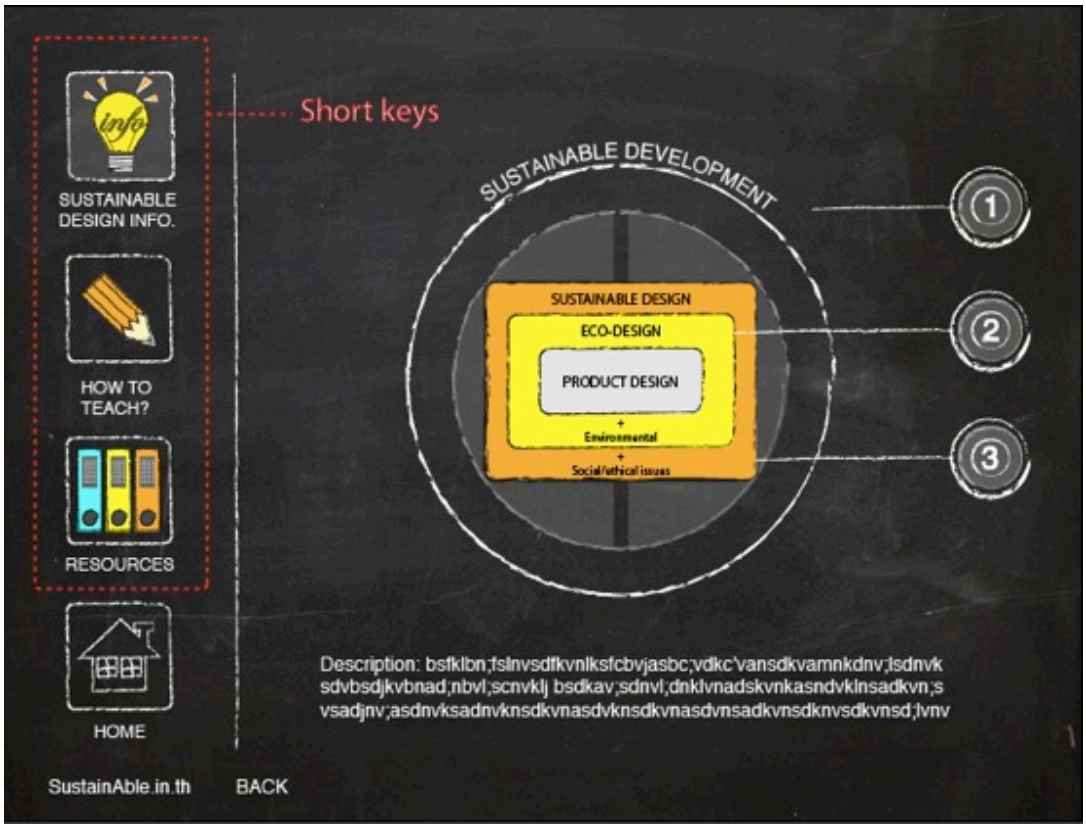


Figure 31: Short keys for navigating users to the first page of each part

5.6.2 Sustainable design information

As discussed in Section 4.4, the target users have gained some sustainable design information and experience, but they could not clearly explain the topic to their students because they do not view sustainability issues holistically and broadly. Consequently, the purpose of the sustainable design information section is to resolve this problem by providing some basic principles that facilitate the target users to broaden their perspective of sustainable design.

Primarily, the relationship between concepts related to sustainability is explained. As discussed in Section 2.8 and Section 4.5.2.1, the design courses already provide the elements of sustainable design, such as 3Rs theory, Thai product design, and OTOP, but they do not connect them together due to the lack of sustainable design lecturers. Section 4.4 identified the majority of Thai lecturers as being novices or advanced beginners who could not clearly explain and enable students to have a holistic view of the concept. This results in the incomplete of sustainable design learning, as most Thai design students apply sustainable design without consideration of the TBL, also known as the three pillars of sustainability. Experts (UNI-1-2-E, UNI-2-1-E) revealed that most students address sustainability issues by focusing on only one or two pillars. The problem-solving solution can address the problems in the focused pillars but it might create negative impacts on the other pillars. For example, a group of students sought to stimulate the local economy of a Thai community and hopefully create a better quality of life through the development of a product. The community originally produced and traded Thai silks that are packed in silk bags. The students offered to redesign the packaging; glossy papers and plastic films were selected to be the main materials. The new packaging might enable the community to increase the retail cost and earn more money but it can also cause more environmental problems due to the waste of packaging and lack of sustainable materials specified.

The diagram from work of Charter and Tischner (2001) was selected for the first page of the information section as it illustrates the relationship between design concepts and sustainability as shown in Figure 32. This diagram was placed to enable

the design lecturers to understand the relationships between concepts related to sustainability and gain a holistic view.

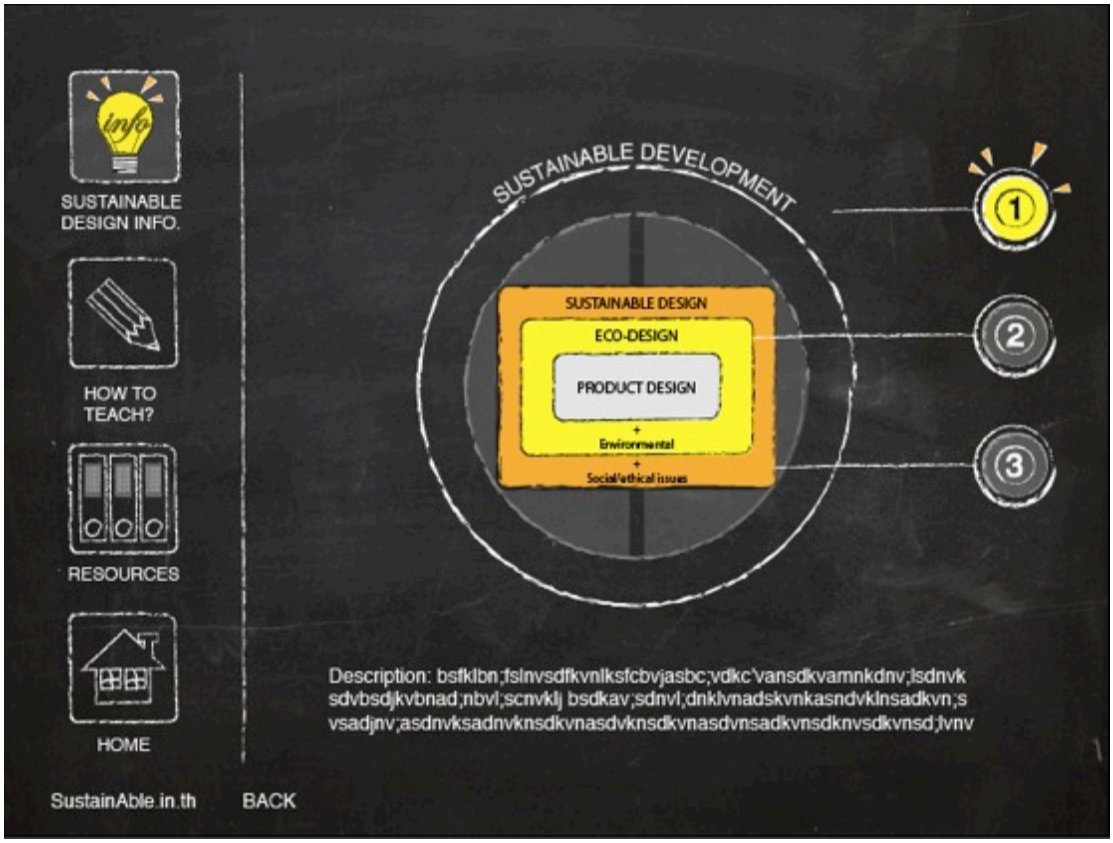


Figure 32: The visual menu for the sustainable design information section

As seen in Figure 32, a short description about the relationship between the concepts is displayed underneath the diagram. The diagram is also used as a visual menu that directs the users to other webpages. Three webpages are provided to elaborate more details of technical terms: sustainable development (call-out 1), sustainable design (call-out 2) and eco-design (call-out 3).

5.6.2.1 Eco-design section

Among the three basic technical terms on the first webpage, eco-design (call-out 2) is emphasised due to the influence from the international market. Section 2.7 identifies the need to integrate eco-design into the Thai manufacturing industry. However most of the current designers fail to apply eco-design due to the lack of a holistic view. An expert in the industry (COM-2) stated that most of the Thai designers overlook the product-life-cycle and consider only a few particular issues while they are designing eco-products. Section 2.3.5 shows that product design

lecturers are in the position that can address the problem but the interviews found that this issue also happens to many Thai product design lecturers especially the target users. The purpose of this webpage therefore is to facilitate e users to extend their eco-design perspective through providing an example of the product life cycle as shown in Figure 33.

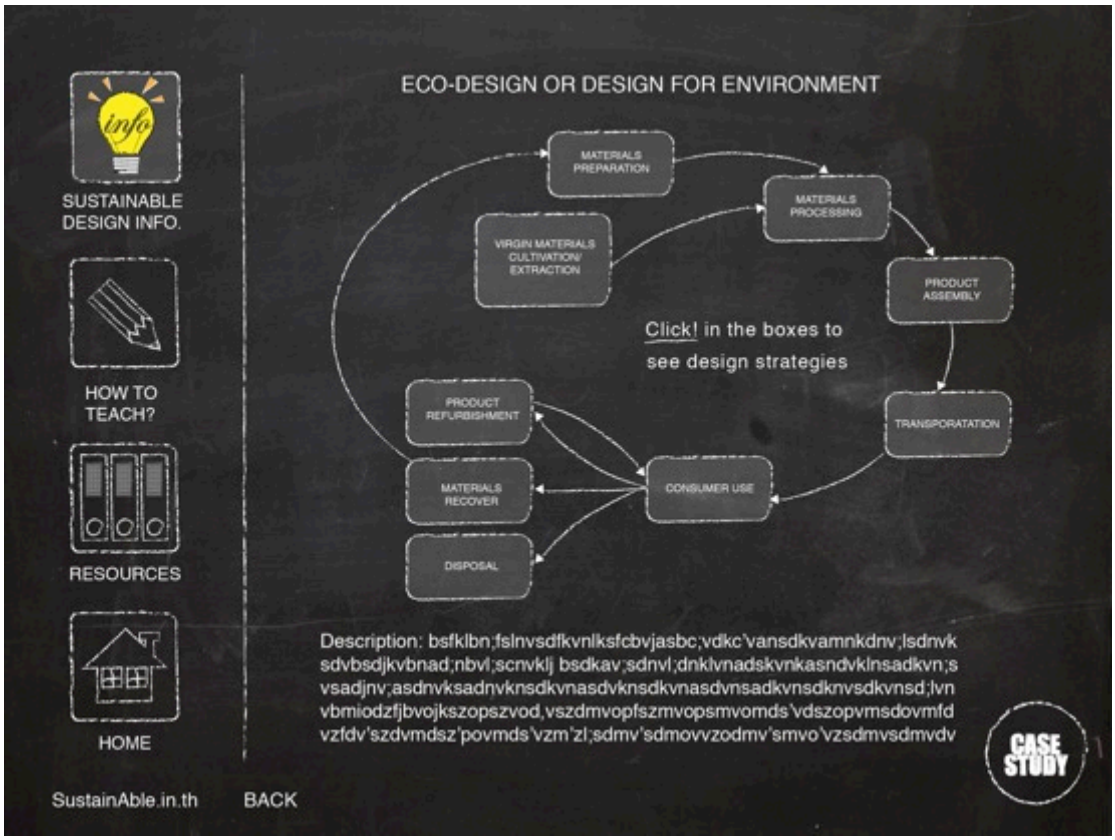


Figure 33: The eco-design webpage that clarifies the concept of the product life cycle

The diagram shows the whole product life cycle from material extraction to the end of product life. The description underneath the diagram underlines that the life cycle shown is only an example; other products might or might not have similar processes. It is also utilised as a visual menu that links to the design strategies webpages. The users can click any processes that they are interested in and access information of eco-design strategies that can be used on each process. For example, Figure 34 presents a set of design strategies that can be used in the material selection process.

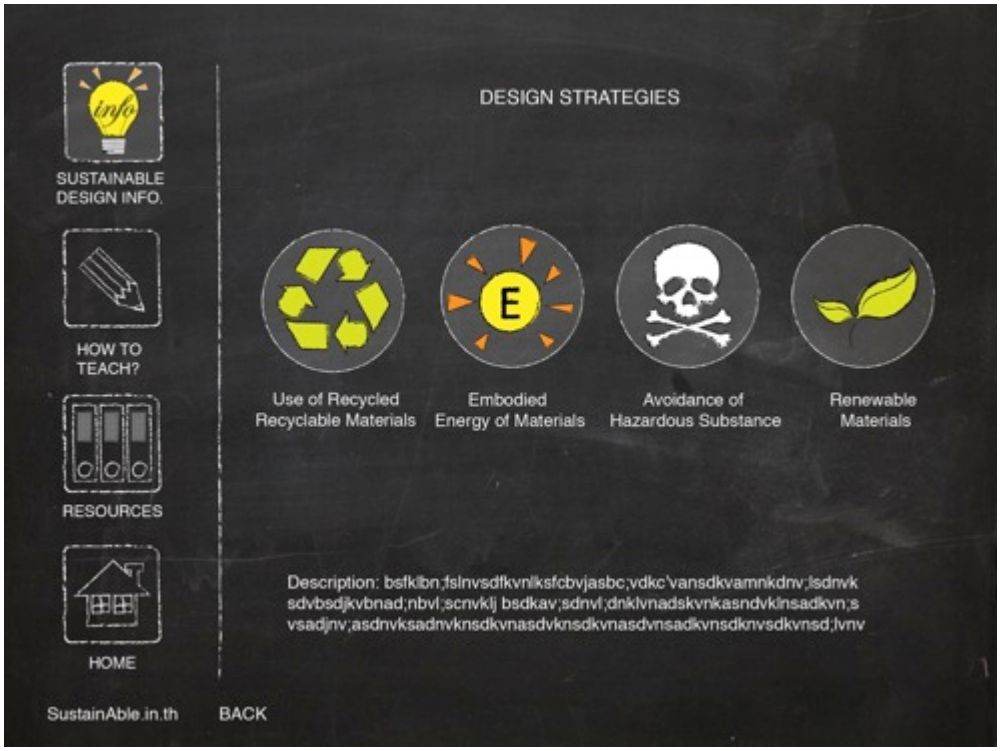


Figure 34: A webpage that shows a set of design strategies

5.6.3 How to teach

This part of the tool aims to encourage users to appropriately select and systematically organise the learning activities in sustainable design classes or modules. The developed framework is placed on the first page of this part as it provides the target users with an overview of an ideal ESD learning approach (shown in Figure 35). The framework is also assigned to be a visual menu that directs the users to other pages that describe the framework in more detail and its origin.

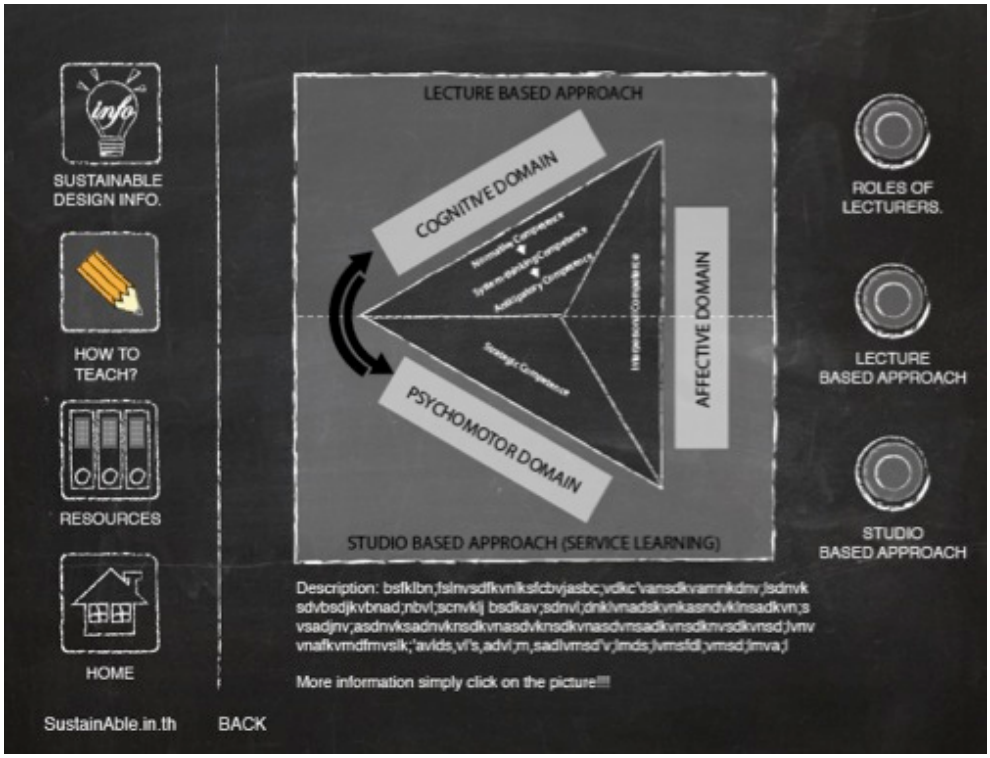


Figure 35: The visual menus for the "How to teach" part, most of the texts in the diagram are hyperlinks that allow the users to access more details

For example, the user can access more information about three learning domains and their relationship by clicking text hyperlinks as seen in Figure 35, which will then bring the users to a webpage in Figure 36 that elaborates on the principles of the three learning domains.

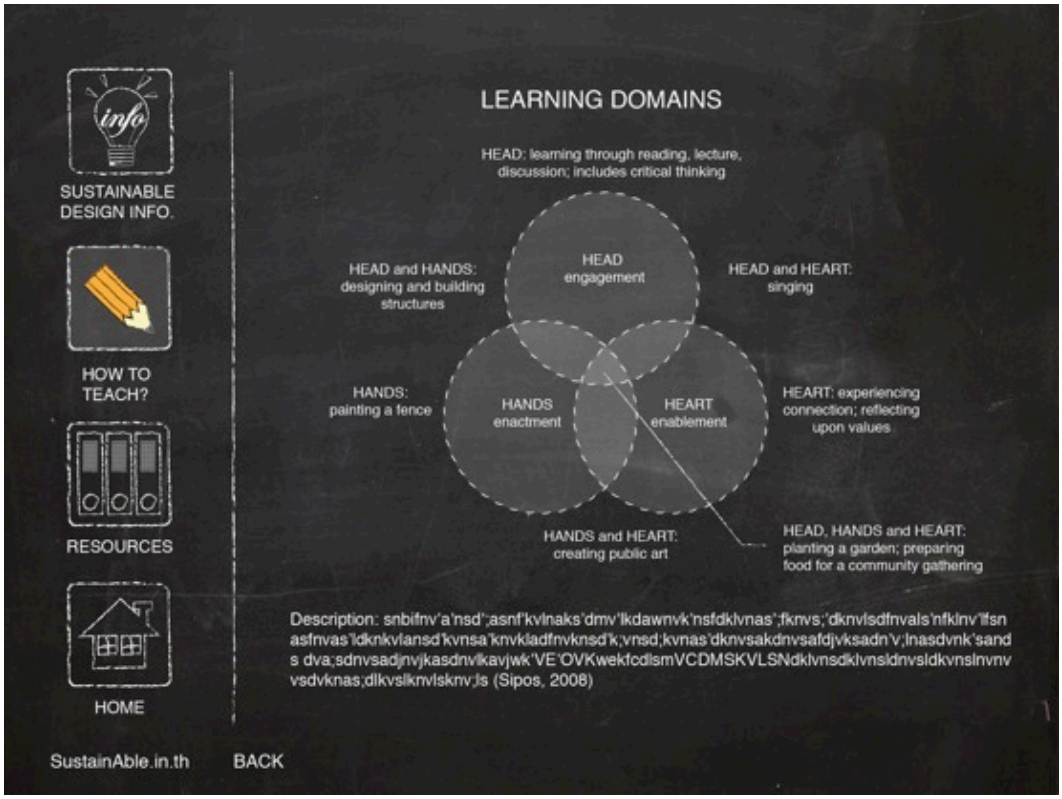


Figure 36: The webpage that explains the three learning domain through diagram retrieved from Sipos et al. (2008).

In addition, this section of the tool also provides some examples of learning strategies that are appropriate to encourage students through the three learning domains by dividing them into two sections based on the two learning types: lecture-based and studio-based classes.

5.6.4 Sustainable design case studies

Chapter 2 and Chapter 4 discuss how many Thai resources fail to transfer eco-design knowledge as the information provided is too complicated and not relevant to designers. To satisfy the criterion in Section 5.3.4 and make the information in the website more appropriate to design lecturers, various design case studies are included to elaborate on and clarify the information. As discussed in Section 2.5.2.1, offering design case studies is one of the most effective ways to educate designers as it complies with their culture (Victoria-Uribe, 2008), therefore case studies were then selected, based on the contents presented in 'the Sustainable Design Info part'. A link to which is also provided on a particular webpage. For example, a link to 'Litre (sic) of light project' is provided on the webpage that presents content related to

social sustainability. The project aims to help people who live in houses that have no access to electricity and light. The bottle light bulb was designed based on local resources and recycled plastic bottles (see Figure 37). The bottle light can be used bring light to poor residents who live in slum areas and runs on a 50-watt light bulb that has five years of useful life (Myshelter Foundation, 2015) (more examples of case studies are provided in Appendix H).

Figure 37: The case study of "A Liter (sic) of Light Project"

Moreover, the selected case studies have been categorised into two groups: Thai case studies and international case studies as shown in Figure 38. This is because the concept of sustainable design is complex and can be differently applied depending on the context. For example, using recyclable plastic is one of the best solutions to reduce environmental problems in western countries. However, this may not be an appropriate strategy for Thailand as the country would be required to import the recycling technologies (UNI-1-4-A). In addition, most of the plastic products are normally sent to landfills with other wastes and never recycled (UNI-1-3-P, COM-4). Although not all cases can be directly adopted into the Thai context, they were still included in the tool as design case studies can enable designers to stimulate new ideas (Bhamra and Lofthouse, 2003).

Figure 38: The first page of sustainable design case studies part

This part of the tool can be accessed through two channels: case study icon and resource short key as shown in Figure 39.

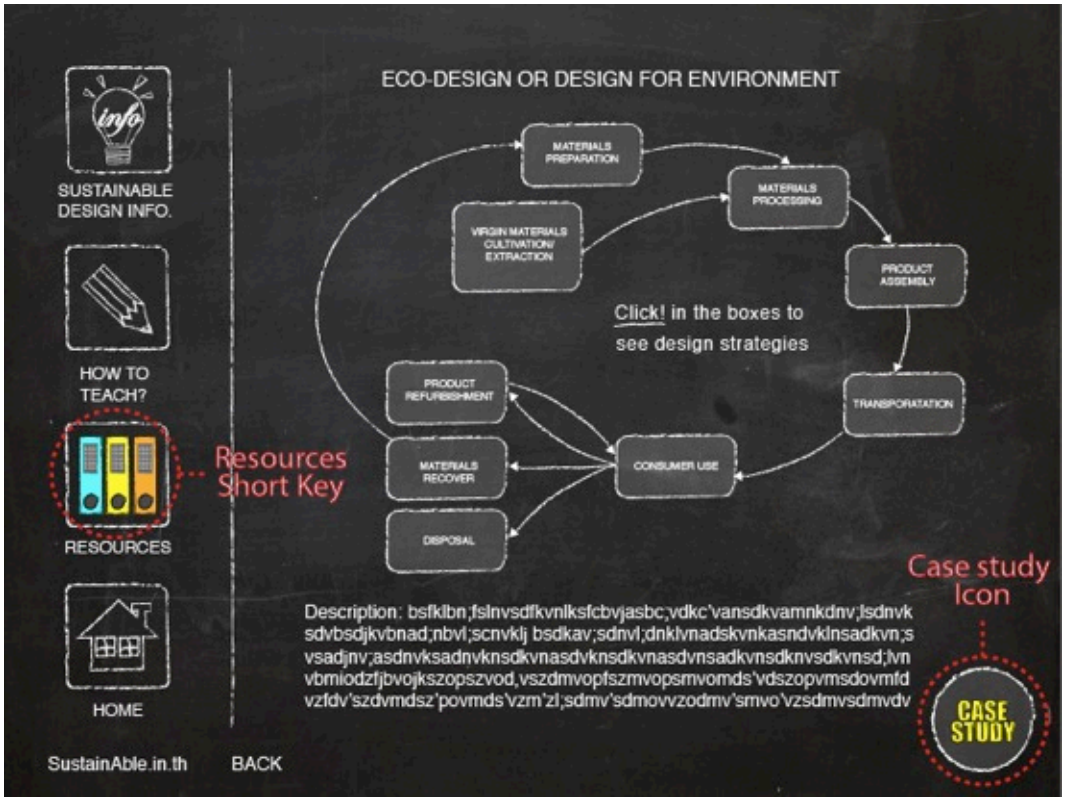


Figure 39: The access to the sustainable design case studies part

The case study icons are located on the webpages in the information section as shown in Figure 39. They will direct the users to a case study that relates to the information provided on each page. The resources short key is provided to offer an alternative way of acquiring information; the short key allows the users to start learning from case studies and link back to the information section. The users can click on the hyperlinks highlighted in the yellow colour as shown in Figure 40.

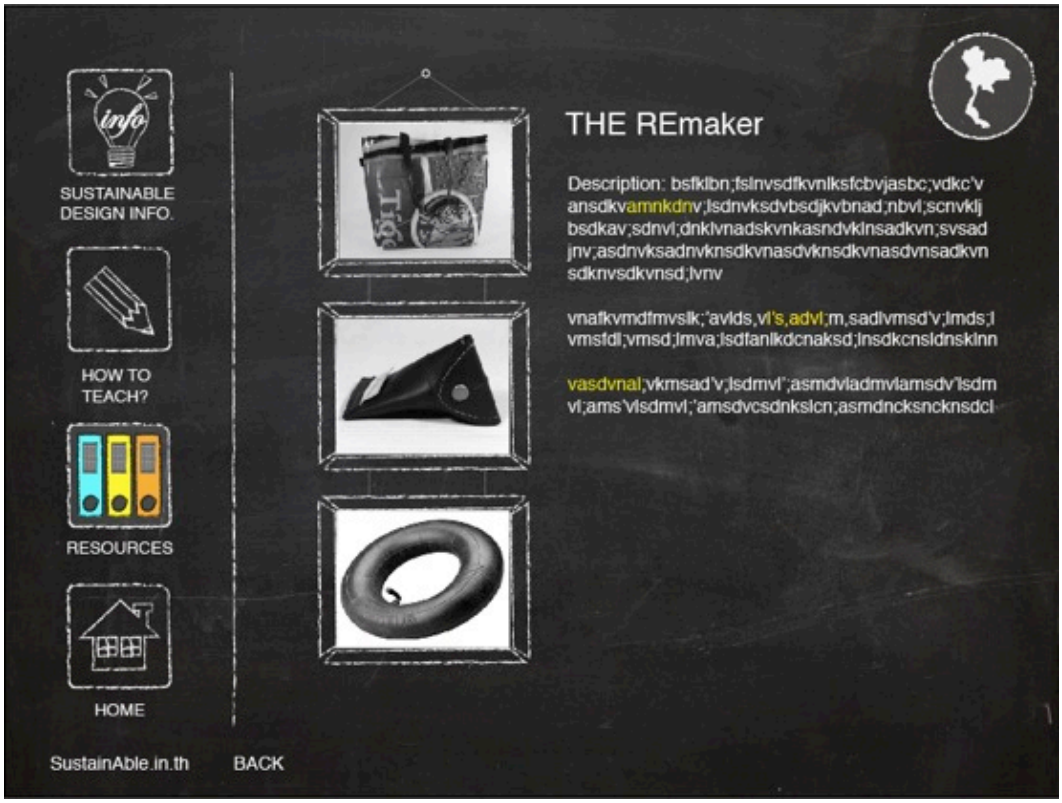


Figure 40: An example of cast study webpage

5.7 Conclusions

Chapter 2 and Chapter 4 identified the need to develop an ESD teaching framework for Thai industrial/product design courses. The interviews with experts revealed that many Thai design lecturers did not have a great deal of insight into sustainable design due to the lack of appropriate training and supporting learning materials. This is because the Thai industrial/product design courses have just started to place an emphasis on sustainable design. Thus, there has historically been a limit in materials that facilitate lecturers to be more competent in teaching sustainable design. Most of the existing materials related to sustainable design learning were developed based on foreigners' perspectives that are not necessarily compatible with the Thai context. Although some materials have been developed in Thailand, most of them were for engineering or environmental science professions. Among a number of support materials, the TQF was considered as the most predominant scheme in Thai HE. The TQF has been widely implemented into all Thai HEIs owing to the drive from the government. Although the TQF was not specific for ESD learning and teaching, it is quite appropriate to ESD as it relies on the output approach (more details

provided in Section 2.3.4). It allows lecturers to enhance their teaching effectiveness through systematic planning and self-assessment. The TQF framework required lecturers to fill in two forms. Firstly, 'TQF 3' is completed before starting a module; lecturers are required to present expected learning outcomes and teaching activities that will be employed to enable students to achieve the specified outcomes. Secondly, in 'TQF 5' the lecturers are expected to report on the results of the modules. However, the implementation of the TQF was not successful in terms of enhancing teaching capability. In Chapter 4, three main reasons that cause the failure of TQF were discussed: (1) it is difficult to understand and apply, (2) it cannot comply with the learning culture of design lecturers, and (3) it is time-consuming. The development of a new framework took into account these three to avoid some failures.

Firstly, Chapter 4 showed that most of the Thai design lecturers have a similar learning culture to designers who require a specific way to acquire knowledge. The TQF presents information through a text format but designers prefer to obtain information that is introduced with less text and in a creative way. Disseminating the new framework through the web-tool potentially addressed this barrier as it allows the use of graphics and interaction (as shown in Section 5.6.3). This can comply with the learning culture of the lecturers and make the content more understandable. Secondly, many participants (design lecturers) were not able to gain an insight into the TQF as the assessment framework does not provide enough information. For example, it suggests that the set of learning outcomes should cover the six domains (learning competencies in the new framework). But it does not provide any advice to help to achieve this goal. The new framework, developed as part of this PhD, not only suggests what to do but also how to do it. Lastly, there is a change of emphasis from time consumed to time saving for lecturers in developing learning materials. Many lecturers feel that they have to spend a long time to complete the TQF paper work. The new framework does not require them to fill in forms, it only presents an appropriate learning pattern that lecturers can apply in their modules. Moreover, it enables the target audience to save time in teaching preparation through providing some guidelines and recommended resources. As shown in Section 5.6.2 and Section

5.6.4, the web-tool offers some sustainable design information and case studies that lecturers can use in their classes. The framework and web-tool were evaluated through the method outlined in Chapter 6, which also discusses and presents the findings obtained from the evaluation.

Chapter 6: Framework Evaluation

6.1. Introduction

This research aims to contribute to the implementation of ESD in Thai industrial/ product design courses through the development of a more appropriate framework for learning and teaching sustainable design. The literature review showed that many existing frameworks and tools have resulted in little progress in integrating ESD into Thai industrial/product design education as they could not match the needs of Thai lecturers. Maguire (2001) underlines evaluation as one of the required processes in the development of any system because it can confirm that the aims and objectives have been achieved. Usability testing was employed as a key method in the evaluation of this PhD project as it allowed the researcher to assess the effectiveness of the framework and web tool. Usability testing has been widely acknowledged and applied into website development as it not only tests the usability of a website but also enables designers to discover any problems in the design prior to the release of a product (Rubin and Chisnell, 2008). Three research techniques: software prototype, observation and interview, were employed to fulfil the usability testing as discussed in Section 6.3. The findings obtained were then analysed through coding and clustering (see Chapter 3). Chapter 6 presents the findings from the evaluation by dividing them into three sections: framework results (Section 6.4), tool results (Section 6.5), and providing case studies (Section 6.6). At the end of the chapter (Section 6.7), all the findings were drawn together and utilised to illustrate how the objectives of this usability testing (presented in Section 6.2) were achieved.

6.2 Aims & objectives

The evaluation proposed to assess effectiveness of both the theoretical framework and the web tool that were introduced in Chapter 5. The set of design criteria presented in Section 5.3 were then used as a basis to develop aims and objectives. The two major aims of this empirical study were: (1) to test if the developed framework would be appropriate for Thai industrial/product design education and could facilitate the target users to enhance their pedagogical skills. (2) to evaluate

the effectiveness of the '*SustainAble*' web tool to disseminate and support the developed framework. Each aim was broken down into the following objectives:

Objectives for the first aim

1.1 To determine the target users' perceived level of familiarity and understanding of the framework.

1.2 To gather users' perceptions on how the framework would be used for planning teaching and whether it could facilitate the systematic construction of their sustainable design classes.

Objectives for the second aim

2.1 To measure the ease of use of the web tool and test whether the target audiences could successfully acquire the information provided.

2.2 To identify barriers that obstruct users in acquiring information from the tool and find solutions to overcome these barriers.

2.3 To determine whether the support elements provided could facilitate the dissemination of the developed framework.

6.3 Methodology

Usability testing was employed in this stage as it allowed the researcher to assess the effectiveness of the framework and the web tool. As presented in Chapter 5, the developed framework will be disseminated through the web tool as it allows the use of interaction and graphics. The web tool contains two major parts 'Sustainable Info' and 'How to Teach' sections. The latter is dedicated to present the developed framework and further explanation. Various case studies to elaborate the contents in both sections are also provided in the web tool, and can be viewed through the links provided (see Chapter 5).

In Chapter 6, the term 'web tool' represents both 'Sustainable info' section and the framework section. The term, 'How to Teach' was selected to indicate to target users the contents that are offered in the section. Websites that are easy to use should inform users with the words that they are familiar with and not require further effort to think (Krug, 2005). The aims and objectives described in Section 6.2 were

considered as goals for the test. In accordance with Maguire (2001), participants of the target users were invited to experience the developed platform and asked to complete tasks assigned. At the end of the test they were then asked to provide feedback on their experiences and interactions. Further details about the research techniques that were employed to fulfil the usability testing of this PhD project are provided in Section 6.3.2 and Section 6.3.3.

Maguire (2001) divides the degree of the test into three levels based on its formality as shown in Table 40.

Table 40: The classification of usability evaluation summarised from Maguire (2001)

Approaches	Characteristics	Application
Participative (less formal)	- no format	To understand users' thinking
Assisted approach (intermediate)	- have an assistant that can provide some help during the evaluation	To fully obtain users' feedback while maintaining the realistic operation
Control evaluation (formal)	- real world environment - users are only allowed to have a manual or help line	To evaluate whether usability requirements have been achieved

Although Maguire (2001) suggests that a control format is appropriate to evaluate the usability of the system due to its formality, it did not fit with this research project as the prototype could not represent the full performance of the final web tool. Some webpages, links, interactions were not available in the prototype version. The assisted approach was therefore selected because it allowed a moderator (the researcher) to inform the participants what the final website would be like when it was completed. Therefore, the moderator only provided information that would be included in the completed web tool. Additional explanations or other information were not given in order to maintain a realistic operation of the web tool.

Moreover, the selected approach allowed the researcher to fully investigate the reaction of the participants through observation while they were experiencing the

prototype of the web tool. As previously mentioned, the evaluation of the framework and the web-tool was divided into three stages as shown in Figure 41.

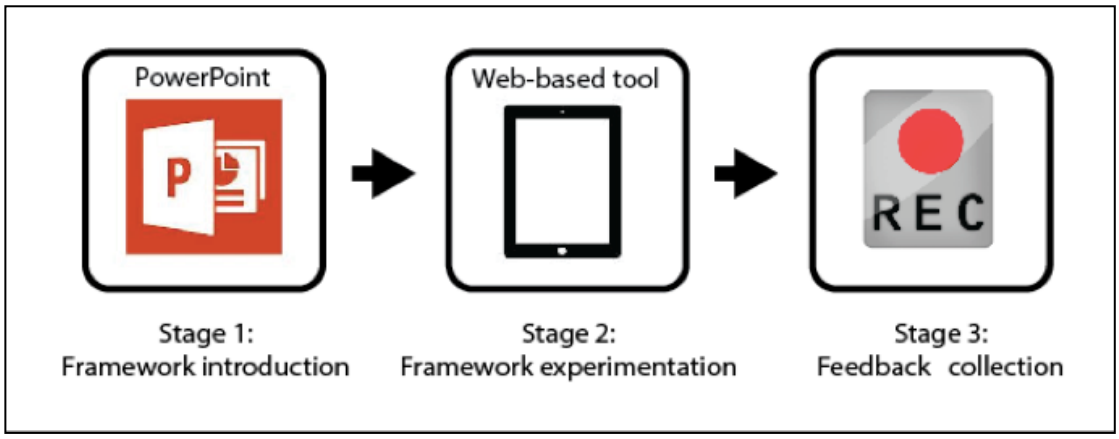


Figure 41: Processes of framework and tool evaluation

This section reveals the usability testing and methods that were employed to support the evaluation through the four following sub-sections; Sampling (6.3.1), Orientation stage (6.3.2), Web tool experimentation (6.3.3), and Feedback collection (6.3.4).

6.3.1 Sampling

The Thai product design lecturers that participated in the previous study (see Chapter 4) were invited to evaluate the developed framework and '*SustainAble*' web tool. They were reclassified into two groups. The first group, target users were comprised of novice and advanced beginner groups (see Section 5.2). There were ten participants from eight industrial product design courses. It was anticipated that their feedback would identify the acceptability of end users and identify problems and be enough to disclose most of the usability problems. Sova and Nielsen (2003) have carried out a large number of usability testing studies and concluded that 80% of usability problems can be found after testing four users.

However, there was still the possibility that the data generated may not be sufficient to identify all the potential problems for the system due to the limited number of participants. Thus, a second group of seven lecturers, classified as expert or proficient (as classified in Section 4.3), were involved in the usability testing. It was anticipated that their opinions would reveal any shortcomings in the system that

were not identified by the previous limited number of participants (Maguire, 2001). The inclusion of participants in the second group was also considered to be necessary as their greater level of knowledge and experience of sustainable design would ensure the framework and tool were suitable for a range of abilities.

6.3.2 Orientation stage

Providing orientation can help participants who are new to usability testing feel more comfortable with the study (Sova and Nielsen, 2003). It informs participants of what they will be doing and activities that will be happen during the test (Rubin and Chisnell, 2008). In this PhD research, a PowerPoint presentation (see Appendix D) was created and utilised to inform participants of forthcoming research activities, and was built based on suggestions of Rubin and Chisnell (2008).

Firstly, the presentation introduced both sections of the web tool. The participants were also asked to complete two tasks, which involved experiencing the two parts of the web prototype, and providing feedback.

Secondly, the testing set up (rooms and equipment) was described. The participants were informed that their voices would be recorded. The instructions for the prototype were also presented in this stage to help the participants to fully access the web tool. Sova and Nielsen (2003) suggest that instruction is required if the participants are not familiar with the technology. Although most were familiar with using the internet on laptops or desktops, the prototype version was presented through a tablet that some were not familiar with (more details about the prototype are provided in Section 6.3.3).

Along with the recommendations discussed above, Rubin and Chisnell (2008) emphasise that it is important to reassure participants that they are not being tested. Thus, the presentation then gave the participants a clear view of the purposes of the usability testing and how their feedback would be used to make them feel free to give opinions.

6.3.3 Framework and web tool experimentation

In this stage, two research techniques were employed to investigate the participants' perceptions and experiences of using the web tool. Firstly, a software prototype: a computer simulation that provides a high level of realism (Maguire, 2001). This technique is widely applied in website development as it allows participants of the target audiences to realistically explore the website (web tool) before it goes live (Maguire, ibid). The prototype can be used to display basic layout, flow of the webpages, and organisation of functions (Rubin and Chisnell, 2008).

The participants were given 15-20 minutes to interact with the software prototype of the web tool that provided example webpages of the two sections: 'How to Teach' (framework) and 'Sustainable Info' sections. Some design case studies were also presented in the web tool to clarify content in the 'Sustainable Info' section. Sixteen webpages were offered in the realistic prototype created through an application called "Picture Link" (Zuhanden, 2014) that provides realistic visualisations (see Appendix 1). Participants could go through a number of webpages and videos as they would do with the final version. Secondly, observation techniques were then employed to monitor the participants during this stage because, according to Robson (2002), feelings and attitudes are not data that can be obtained through asking questions. Sitting next to participants enables the researcher to gather their first impression about the prototype (both design and functions) and to ask follow-up questions about their actions (Rubin and Chisnell, 2008). In addition, note taking was also used in this PhD study to capture participants' actions.

6.3.4 Feedback collection and data analysis

After the experimentation stage, post experience interviews with the participants were employed as they allowed the researcher to collect subjective feedback from participants of the target users and sustainable design experts (as discussed in 6.3.1). Chapter 3 presented three types of interviews and their applications. Unstructured interviews and open-ended questions were selected as they allowed participants to freely express their opinion. Two questions were initially asked in this stage to encourage conversations: (1) What do you think about the framework? (2) What do

you think about the tool? After that, the conversations were developed based on the interests of the participants.

In the next stage, coding and clustering was used to analyse the findings obtained from both observations and interviews. These are presented as: framework evaluation results (6.4) and web tool evaluation results (6.5).

6.4 Framework evaluation results

This section discusses the findings of the study related to the 'How to Teach' section (developed framework), which were grouped in various sections based on themes that emerged during the process of coding and clustering.

6.4.1 Sustainable design competencies element

According to Chapter 5, a set of six competencies initially developed from Wiek et al. (2011) is considered as ESD learning outcomes for learning and teaching sustainable design in Thai industrial/product design courses because it is compatible with the design profession. The set was presented in a problem solving format that is related to industrial/product design profession. Moreover, the selected set also covers two required abilities: normative and strategic competences that are required by the manufacturing industry (as seen in Section 5.4.1). Most of the participants in the expert group agreed that the selected competencies are appropriate for ESD learning. However,, two experts (UNI-1-2-E, UNI-2-1-E) were concerned that it was selected based on foreigner perspectives that are quite different to the Thai learning culture. One said, *"I have no problems with the selected set of competencies but some lecturers might not appreciate the western idea because of the difference in contexts"* (UNI-2-1-E).

Despite the experts' concerns, the interviews with the participants of the target users revealed that they agree with the set of competencies provided. The findings also indicate a usability problem in the competencies element; the participants struggled to understand the competencies diagram (presented in Figure 35) as they were not familiar with the terms used to explain it. During the test, many participants requested further explanations to elaborate the terms. According to one

participant *"The jargon should be clarified to ensure that all lecturers will understand"* (UNI-1-4-A).

Some of them did not ask for the explanation but only gave minimal feedback on the competencies diagram. The researcher then prompted them to discuss the topic further and, in doing so, observed their reactions to gain more feedback and check their understanding. The interviews demonstrated that they were able to understand the set of competencies after clarification was given. They also agreed that Thai design students are required to acquire this set of competencies to engage with and learn sustainable design principles.

In addition, an expert (UNI-1-2-E) suggested that the competencies would be more understandable and more appropriate if they were linked with theories or principles that are well known in Thai HE. For example, by linking the two conditions of SEP: knowledge and morality (see Chapter 4), knowledge could be linked to normative, systems thinking, and anticipatory competencies. The interviews discovered that most of the participants of the target users only discussed and provided feedback on competencies related to cognitive and psychomotor domains. While feedback from participants in the expert group covered all three learning domains. An expert recommended that morality should be included in the set of competencies. *"Selfish people will not consider real sustainable design as they do not respect and care others"* (UNI-1-2-E). An expert (UNI-2-1-E) revealed that she has no problem facilitating students to achieve competencies related to sustainability values or affective domain but it is challenge to encourage them to maintain these values in real life as their working environment usually reinforces economic rationality.

6.4.2 Triangle learning domains element

As discussed in Chapter 5, Bloom's taxonomy (1956) was applied to develop the framework because it can influence deep changes in knowledge, skills, and attitudes that are required for sustainable development. As was the case with the competencies, the experts were concerned that this element might not be accepted as it was built from a foreigner's perspective. However, the empirical studies proved that the participants of the target users could clearly understand the triangular

element and agreed that it is required for ESD learning. The participants demonstrated their understanding through linking the framework with their previous teaching experience. For example, a lecturer mentioned that *"I usually focus on the psychomotor domain as design students prefer to learn through practicing design"* (UNI-3-1-P). According to the interviews, most of the participants had a good comprehension of this framework element because they felt familiar with the 3 domains. Firstly, some participants were aware of Bloom's taxonomy and/or other similar concepts. A few lecturers (UNI-8-1-N, UNI-9-1-A, UNI-4-1-N) had obtained master's degrees in design education and mentioned that they had heard about the taxonomy when they were studying. Moreover, experts (UNI-1-6-P, UNI-2-1-E) revealed that the three domains overlap with the five domains concluded in the TQF (see Chapter 4). Secondly, the three learning domains are naturally related to the teaching activities in product design courses, which usually involve at least two domains: cognitive (lecture-based learning) and psychomotor (studio-based learning). In addition, many participants agreed that it is one of the roles of lecturers to teach students to have a good attitude. For example, *"… once one of my students sent me a design proposal to develop a set of furniture for whisky drinkers. I then encouraged them to change the topic as it is not good to encourage people to drink alcohol"* (UNI-1-1-C). However, the discussions related to affective domain was relatively low if compared with the other two domains. Most of the conversations related to sustainability values appeared in the interviews with participants in the expert group.

6.4.3 Two major learning types element

As discussed in Section 5.4.3, this part was developed based on the learning pattern that the target users used to teach sustainable design. The findings from the usability test showed that all participants agreed that sustainable design should be taught through both lectures and studio-based practice. One of them mentioned that "*design students usually prefer to learn through designing products but lecture-based learning is still required. It provides design principles that allows students to shift from craftsmen to designers*" (UNI-3-1-N).

The findings from the empirical study showed that the two major learning types presented in Section 5.4.3 enabled the participants to link the framework with reality. They were able to see how it related to the learning and teaching in Thai industrial/product design courses. The discussions related to the framework were stimulated after the participants had read the explanation of this element. For example, *"I already employed some learning activities that related to the three learning domains in my studio classes*" (UNI-8-1-N).

6.4.4 Issues related to level of understanding of the target users

During the post-test interviews, all participants revealed that they were able to understand the framework. However, the findings from both the observation and the interviews showed that the participants have gained deep understanding and surface understanding.

Participants who gained deep understanding comprehensively understood the framework. During the interview sessions, they were able to immediately link their previous teaching experience with most of the elements of the framework. They also provided some teaching cases as displayed below:

> *"I usually teach students through this (psychomotor) domain as design students prefer to learn through studio-based classes that provide them opportunities to practice design"* (UNI-7-1-N).

> *"I have engaged students through the psychomotor domain. The students were assigned to develop products by utilising waste from the manufacturing processes. In the modules, they also got opportunities to work with the manufacturers and visit the sites"* (UNI-6-1-N).

Although the participants at this level clearly understand most of the framework elements, the findings still discovered two concerns. Firstly, they initially struggled to gain understanding of the competencies element. The terms used were too complex and required to be replaced with more appropriate terms (see Section 6.4.1). Secondly, the participants gave less consideration to the affective domain (third learning domain). The findings showed that the participants have understood the

basic concept of affective domains but could not confirm that they would focus on the strategies in this domain. The post-test interview implied that the participants only gave little interest on the affective domain as reflected through the discussions that emerged. Discussions related to cognitive and psychomotor domains were more apparent in the interview with the participants.

Those who gained surface understanding (3 out of 10 participants) verbally responded that they were able to understand the developed framework but provided fewer teaching cases and discussions than the others. They also requested examples that can be used to elaborate the framework elements. *"Can you give me examples about engaging students through the affective domain"* (UNI-1-5-N). Although they did not demonstrate that they clearly understand the framework, they showed intention to apply the framework to complete the TQF form (see Section 6.4.5). The findings also noted that providing case studies allowed the lecturers to gain a better understanding and shift to a deeper understanding (see Section 6.6).

6.4.5 Issues related to Thai Qualification Framework (TQF)

The 'TQF' is quite similar to the developed framework as it also relies on the output approach (see Chapter 4). Many participants, both expert and participants, noticed some similarities between the TQF and the framework. An expert (UNI-2-1-E) showed her concern that the developed framework might not be compatible with the target users as the TQF has not been successfully implemented in the Thai education system as it is not able to satisfy the need of many lecturers as it increases their workload and has only one format but each discipline requires different ways to acquire knowledge (see Chapter 4).

However, another expert (UNI-5-1-P) argued that the framework is more understandable than the TQF and appropriate to Thai industrial/product design education. The expert was also confident that the target lecturers would apply it due to its advantages in teaching preparation. The interviews with the participants also supported the expert opinion. 8 out of 10 lecturers felt that it would be useful and they were willing to apply it to select the teaching strategies and construct

sustainable design classes. One of the participants mentioned that "*The web tool helps me to gain better understanding on sustainable design and gives me idea to select learning activities*" (UNI-1-1-C).

In addition, experts (e.g. UNI-2-1-E, UNI-5-1-P) also confirmed that the framework together with the web tool is appropriate for the target lecturers. Moreover, the findings found that the framework could enable some participants to gain better understanding of TQF. An expert (UNI-5-1-P) mentioned that the target lecturers could utilise the new framework as a guideline to complete the TQF form. Indeed, a few participants revealed that they would utilise the framework to help them do this. *"It seems to be a TQF support tool, I can use this framework to complete the TQF form number 3"* (UNI-4-1-N).

6.4.6 To apply rather than adopt

The findings obtained from the usability testing confirmed that the developed framework can facilitate the target lecturers to teach sustainable design. But the lecturers should not adopt the whole framework to their classes without critical planning because of two main reasons:

Firstly, the web tool might obstruct lecturers' self-development as it might lead them to be inactive. An expert (UNI-5-1-P) underlined that the combination of the framework and 'Sustainable Info' section can be considered as a ready-to-use toolkit. It provides all basic content required for teaching sustainable design. However, another expert (UNI-3-2-E) was concerned that *"It might make some lecturers be inactive and not keen to develop their own teaching plans"*. In other words, some might just directly adopt the framework in classes without further research that allows them to develop their pedagogical skills. Another expert (UNI-3-2-E) also gave caution that some might directly use the information provided to complete the TQF forms without having a clear understanding of the framework.

Secondly, the developed framework has to be adapted based on the nature of classes and students. The empirical study confirmed the findings from the literature review that it is no-one-size-fits all approach. Students in different groups have different characteristics and learning cultures. For example, a participant revealed

that *"I have no problem with the affective domain as my current students are excited to learn this topic"* (UNI-2-1-E). While another mentioned that *"my students feel that the concept limits their creativity"* (UNI-1-3-P). Although there was a concern that the target lecturers would directly adopt the framework, the interviews with participants discovered that they have a low tendency to adopt the whole framework. A participant mentioned that it is unlikely "*lecturers [will] adopt the whole framework into their classes as everyone has their own ego. I will only take some parts and adapt it …"* (UNI-2-3-N). Moreover, many participants showed their ideas to apply the framework while considering the nature of their modules. For example:

> "*I prefer to focus on competencies related to the psychomotor domain as my module is ceramics and require lot of practicing*" (UNI-3-1-N).
>
> "*I will start to engage students by using activities associated with the affective domain as they can help me to catch students' attention and increase learning capabilities*" (UNI-4-1-N).

6.4.7 Issues related to the applications of the framework

As discussed in the previous section, the participants showed their different ideas to apply the framework to improve their teaching performance. This section presents the three applications, which were mentioned during the post-test interviews.

Firstly, an expert (UNI-1-7-P) considered the framework as a guideline for teaching planning. The interviews with participants showed that the framework provide them an overview to teach sustainable design. However, they still required additional information to fulfil their teaching and apply the framework in their classes. *"It give me whole picture of how to teach sustainable design but I need to do further research to get more details and know what to apply in my class"* (UNI-1-5-N). Another participant also agreed and mentioned that *"the framework is a guideline that allows me to explore all ESD elements and can make my teaching plan to be more systematic"* (UNI-4-1-N).

Secondly, participants in the expert group suggested that the framework can be employed as an assessment tool. According to the interviews, some participants have carried out a number of learning activities and engaged students through all three domains (head, heart, and hands) but, they have never arranged them systematically. The framework allows them to assess their previous teaching activities and be more systematic in planning their teaching through self-reflection.*"I have only taught based on my previous experience and my understanding. This framework helps me to reflect on what I have done"* (UNI-1-1-C).

Lastly, the framework was considered as a supporting tool for the TQF, an expert found that it could potentially help lecturers to have a better understanding of the TQF as it was developed based on the same approach. *"this framework facilitates the lecturers to gain better understanding on the TQF and find out what to fill in the TQF forms"* (UNI-5-1-P) (see Section 6.4.5).

As previously mentioned in Section 6.4.4 the participants were divided into two levels according to their deep and surface understanding. The former showed their intentions to utilise the framework as a guideline or assessment tool, whereas the latter only introduced the application in supporting the TQF.

6.5 Web tool evaluation results

The empirical study showed that most participants appreciated the web tool. They agreed that it is useful to, and appropriate for, Thai industrial/product design lecturers. *"It is great to have the tool specifically developed for design lecturers"* (UNI-8-1-N). This section presents findings related to the web tool by dividing them into three groups based on the previously identified themes.

6.5.1 Need for 'Sustainable Info' section to implement the framework

As discussed in Chapter 5, the '*SustainAble'* web tool was developed to disseminate the new theoretical framework. The 'How to Teach' section is reserved to present the framework; graphics and interaction were used to satisfy the need of design lecturers for a familiar learning culture. The 'Sustainable Info' section supports the use of the framework in practice through providing some basic principles of sustainable design. Chapter 4 discovered that most of the participants were not able

to clearly explain sustainable design as they were not aware of the basic theory. The framework evaluation demonstrated the 'Sustainable Info' section successfully performed its tasks in supporting the implementation of the developed framework. Details are discussed in the sub-section below:

6.5.1.1 Enabling lecturers to expand sustainable design knowledge

As mentioned in Section 5.6.2, the 'Sustainable Info' section aims to enable the target lecturers to map their previous sustainable design experience and clearly explain it through providing some basic principles (see Section 6.5.3). The empirical study confirmed that the information offered was appropriate. After experiencing the prototype, most of the participants showed that they had gained a better understanding of sustainable design. Most of the lecturers were able to broaden their knowledge and discuss sustainability issues with the full spectrum of the TBL.[5]

> *"I have assigned students to design OTOP products but did not encourage them to consider environmental aspects. I will later influence students to consider all sustainability aspects*" (UNI-6-1-N).

6.5.1.2 Use as a sustainable design resource

The empirical study showed that participants in both the expert and target user groups appreciated the sustainable design information - both principles and case studies due to advantages discussed below:

Firstly, some participants revealed that they would introduce the web tool as learning material for students to their students as the information provided is comprehensive and appropriate for designers.

> *"It would be useful to give students an access to the site. There are no appropriate learning resources available in Thai*" (UNI-1-3-P).

> *"I will suggest to my students to go through the website*" (UNI-5-1-P).

[5] Chapter 2 and Chapter 4 discovered that sustainable design activities in Thailand usually carried out by focusing on either social or environmental aspects. The principle of the TBL was then selected as one of the core contents to influence a more holistic view of sustainable design (more details provided in Section 5.6.2).

Secondly, some participants revealed that the web tool will help them in teaching preparation and enable them to save time when preparing learning content as they can bring the information and case studies provided to discuss in their classes. Some participants also requested that the web tool should offer more information and case studies. Although the information and case studies provided were considered quite useful, the findings identified an error that could happen. An expert cautioned that some target users might misunderstand and wrongly interpret the information and case studies provided, *"…some case studies provided are based on the context of other countries. The lecturers might just take the design case studies to teach students without a clear understanding of these cases"* (UNI-1-2-E).

6.5.2 User interface and graphic design

The findings from post-test interviews showed that the design of the user interface could not satisfy all the participants' needs. Firstly, some of the lecturers revealed that the design of webpages should be developed in terms of the aesthetic and interaction.

> "*The design of the web looks too serious; it should be more friendly"* (UNI-1-3-P).
>
> *"I expect it to be more exciting and more attractive*" (UNI-6-1-N).
>
> "*It looks boring; better put in more interactions*" (UNI-1-4-N).

Secondly, it was found during the interviews that the use of language obstructed many participants in interacting with the web tool. According to Sova and Nielson (2003) and Krug (2005) descriptions presented in a system should be the same as the spoken languages of the users. Two experts (UNI-1-2-E, UNI-2-1-E) also suggested that Thai lecturers might not be familiar with some of the technical terms provided in the tool and this could obstruct them in exploring the site. For example, "*The term Triple Bottom Line (TBL) should be changed to 3P; people, profit and planet" (UNI-1-2-E).*

However, the empirical study showed that the design of the user interface was successful in delivering the information to the participants. The observation revealed that most of the participants were able to find links to other webpages and explore

most of the webpages without any assistance. Moreover, many lecturers (both participants and experts) appreciated the use of diagrams and graphics as they enabled them to acquire the information in a short period of time and was considered more attractive than a purely text-based format.

> *"You come to the right way, it is more interesting and understandable to present the information by using diagrams"* (UNI-1-1-C).
>
> *"The info-graphic facilitated me to obtain the information; it is much easier and faster than reading a long article"* (UNI-5-1-P).

6.5.3 Issues related to contents provided in 'Sustainable Info' section

The empirical study confirmed that the contents provided in the 'Sustainable Info' section were considered appropriate. The prototype offered three basic pieces of content: TBLs, product life cycle, and difference between sustainable design and eco-design. These were selected based on the problems that occur in Thai industry (see Section 5.6.2). The empirical study showed that the contents allowed the participants to broadly view sustainability issues and gain a better understanding of sustainable design. For example, a participant (UNI-9-1-A) initially understood that eco-design and sustainable design are similar. After experiencing the tool, the user started discussing social sustainability in the interview session. "… *so universal design contributes to sustainable development through social aspect…"* (UNI-9-1-A).

Experts also approved that the content provided was suitable for Thai product design lecturers due to two main reasons. Firstly, it enables the target lecturers to clearly understand the concept of sustainable design and eco-design. One expert said "*I agree that the diagram here can help lecturers to have a clearer view on sustainable design. Many Thai lecturers always believe that sustainable design is similar to eco-design"* (UNI-2-1-E). Secondly, the contents are comprehensive and only required a short time to understand. While experiencing the 'Sustainable Info' section, an expert mentioned that *"It can be used as an introduction to sustainable design. I am fairly confident that lecturers will use it because it is inclusive and only requires a short time to read"* (UNI-5-1-P).

In addition, the findings showed that the contents related to environmental sustainability seemed to be more understandable than those related to social sustainability due to the strong tradition of eco-design in Thailand (see Chapter 2). Many of the participants gave quick responses to issues related to environmental aspects, while providing a slow response to discussing social sustainability issues. Two participants in the expert group agree that environmental sustainability is easier to understand and teach. *"It is easier to teach eco-design as it is directly related to manufacturing processes"* (UNI-1-7-P). Another expert (UNI-1-2-E) revealed that she had taught sustainable design by starting from environmental aspects as students already have some background knowledge. *"The topic related to environmental sustainability has been introduced in school or mass media"* (UNI-1-2-E).

6.6 Relevance of case study approach

The empirical study showed that providing case studies is useful and enables the target user participants to clarify the complex information and gain a better understanding of the information provided. The interviews found that the target lecturers preferred to acquire information through design case studies as these elaborate how the concept can be implemented in the product development. And explain information in a visual format that is compatible with the learning culture of designers, discussed in Chapter 2.

Along with the benefit of clarifying sustainable design principles, the findings from the framework evaluation revealed that the case studies can also be used to clarify the framework. Experts (UNI-1-3-P, UNI-1-6-P) suggested that examples or case studies should be attached to the new teaching framework as they could help the target lecturers to be more competent in applying it. 7 out of 10 participants also requested examples while experiencing the 'How to Teach' section.

The studies showed that some of the participants struggled to understand the framework because they are not familiar with the technical terms, such as psychomotor domain, affective domain, and competence, used in the education field. Most of the target lecturers requested additional information to elaborate on these terms which they considered to be jargon. The empirical study showed that

case studies were useful aids in helping the participants to clarify these terms and, therefore, gain a better understanding of the framework. For example, the case of Lehtonen (2012) was used to explain how to engage students through the affective domain. In the case, students were asked to calculate the carbon footprint that occurs from the activities in their daily life. The Calculator[6] is a web-based tool that requires users to complete the questionnaire about resources they use in their daily life. After calculating their carbon footprint, most of the students felt guilty and showed more concern to learn sustainable design.

In addition, appropriate case studies can encourage Thai lecturers to place more emphasis on teaching sustainable design. Experts (UNI-3-2E, UNI-5-1P) noted that some target lecturers might be aware of sustainable design but do not acknowledge the need to teach the concept. A lecturer (UNI-1-1C) suggested that examples that show the negative impacts of unsustainable products potentially encourage them to pay more attention to the topic and discuss sustainable design in their classes.

6.7 Conclusions

The framework and web tool presented in Chapter 5 were specifically developed for the Thai industrial/product design education. They propose to facilitate the target lecturers to increase capability in teaching sustainable design to undergraduate students. Usability testing was employed to evaluate the following questions: (1) Is the developed framework appropriate for the target lecturers and can it support them to enhance their capability in teaching sustainable design? (2) Does the 'SustainAble' web tool effectively disseminate and support the developed framework? Section 6.2 presented a set of objectives that were developed based on these two aims and design criteria presented in Section 5.3. In this conclusion, the findings obtained from the usability testing are drawn and used to illustrate how the objectives were achieved.

Objective 1.1: To determine if the target users perceived a level of familiarity and understanding of the framework.

[6] More details can be seen through footprint.wwf.org.uk

According to the findings obtained from the evaluation, all participants of the target users reacted that they feel familiar with the framework through linking its elements with their previous experience. During the post-test interviews, the three learning domains element (Section 5.4.2) and two learning types element (Section 5.4.3) were frequently mentioned, while, the participants struggled to understand the competencies elements (Section 5.4.1) due to the complex technical terms used. The experts suggested that the competencies element would be easier to understand if it could be linked with the principles or theories that are well known in Thai education. In addition, the evaluation discovered that some participants acquired surface understanding and some acquired deep understanding (see Section 6.4.4).

Objective 1.2: To gather users' perceptions on whether the framework could facilitate the target lecturers to systematically construct their sustainable design classes and how the users would utilise the framework in their teaching planning.

Section 6.4 found that the participants differently applied the framework based on their understanding. Firstly, those with a deep understanding showed that the framework enabled them to systematically construct their classes. They highlighted their intentions to utilise the framework as an assessment tool and/or a guideline for teaching planning (see Section 6.4.7). Secondly, the interviews showed that the framework enabled the participants with a surface level understanding to gain a better understanding of TQF. They also showed an intention to use the framework as a guideline to complete the TQF form. However, the findings could not confirm that the participants in this level would utilise all advantages of the framework as they did not fully demonstrate their understanding during the test and interviews.

Objective 2.1: To measure the ease of use of the web tool and test whether the target audiences can successfully acquire the information provided.

Although some of the participants suggested that the tool should be improved in term of aesthetic and styles, its user interface successfully delivered the information to the participants who were able to find link buttons and went through most webpages of the prototype.

Objective 2.2: To identify barriers those obstruct users in acquiring information from the tool and find solution to overcome these barriers.

According to the usability testing, the major barrier was the language use in the web prototype. Some webpages were presented through some complex technical terms (especially in the field of education). Experts suggested that technical terms in the web tool should be replaced with the terms that are widely used in Thai industrial/product design education.

Objective 2.3: To determine whether the support elements provided can facilitate the dissemination of the developed framework.

The evaluation concluded that the support elements are required to disseminate the developed framework. Firstly, the 'Sustainable Info' section together with the cases provided enabled the participants to gain a better understanding of sustainable design and related concepts. In addition, the findings showed that adding case studies related to the framework is required as it allows the target lecturers to gain a better understanding of the framework. Secondly, the elements potentially enable it to be more widespread as the information provided can attract the target audiences. The findings found that most of the participants appreciate the contents provided in the elements as they are directly related to designers. Lastly, experts agree that the web tool is served as a one-stop-service that requires a short period of time to acquire information (theory, strategies, and case studies), while existing materials require more time and effort to understand and apply.

In addition, the findings confirmed that the framework achieved its aim in supporting the Thai industrial/product design lecturers (participants) to enhance their capability in teaching sustainable design. The framework enabled the participants to gain an overview ESD and be more systematic in constructing sustainable design classes. However, the findings could not confirm that the target lecturers would ideally teach sustainable design, enabling students to achieve knowledge (head domain), skills (hands domain), and values (heart domain) required for sustainable development. The findings showed that most of the participants gave

more focus to competencies in the head and hands domains. They provided very little discussion on acquiring competencies in the heart domain.

Chapter 7: Discussion

The findings obtained throughout this research project are drawn together and discussed in this chapter. The discussion starts by providing the overview of ESD in industrial/product design education in general (Section 7.1). The discussion then scopes down to the specific context of Thailand (Section 7.2) and identified the main barriers that obstruct ESD implementation in Thai design education (Section 7.3). Section 7.4 discloses how the decisions were made in the process of framework development and also presents the specific characteristics of the new framework. Sections 7.5 and 7.6 emphasise the findings obtained from the evaluation stage through identifying four keys to success for the development, and discusses the potential of the framework in the reality.

7.1 Overview of ESD in industrial/product design education

The literature review shows that designers are directly related to the implementation of sustainable development in the manufacturing industry as they play roles in selecting materials and processes. Moreover, they can influence user behaviour to be more sustainable through designing the new lifestyle. Education is considered as an imperative element to achieve the integration as it supplies future industrial/product designers with sustainable design qualifications. Section 2.3.2 shows how ESD is the approach to reorient the existing education systems to be more appropriate to sustainable development. As illustrated in Section 2.3.4, the traditional approach that has been widely applied in education systems cannot fulfil the requirements of sustainable development. Learners (designers) are required to achieve knowledge, skills, and values inherent to sustainability for achieving sustainable design implementation. Enabling learners to break their mind-set (economic values) and acquire the new values (sustainable development) is highlighted as a key to success ESD. The appropriate values can influence learners to act and live sustainably. In other words, the sustainability values encourage designers to make decisions with consideration of environmental and social impacts. Most of the material and process selections are traditionally made based on economic reasons of cost and profit. Moreover, traditional education focuses on preparation of learning content that is not compatible with sustainable

development. Sustainable development issues and challenges are varied and can be changed over the time. An output approach is then more suitable as it emphasises enabling learners to acquire competencies.

Several active learning strategies have been introduced and utilised to facilitate the output approach. Active strategies are associated with the output approach as they provide learners opportunities to participate with others. This allows them to acquire the higher retention rate and deeper understanding than traditional lectures that rely on one-way communication (see Section 2.6.2). Although the output approach and active learning strategies are more compatible with ESD than the traditional approach, the lecture method is still required due to its benefits. Firstly, it is time and budget saving, and only requires one lecturer to deliver a large amount of information in a limited time. Secondly, it is simple and flexible and most learners are familiar with the lecture method. It is easy to adapt to be compatible with all target audiences. There is no one-size-fit-all approach for ESD, each country has its own sustainable development challenge and learning context. Both traditional lectures and active learning can facilitate the knowledge transfer of sustainable development. Lecturers play a crucial role in selecting an appropriate set of teaching strategies that is compatible to their own context. However, the findings found that lack of lecturers with ESD qualifications is one of the common barriers to ESD implementation. Facilitating lecturers to acquire ESD qualifications is then required to achieve its implementation.

7.2. The specific context of Thailand

Exploring the Thai context is considered as one of the main objectives because it is required to develop the material/solution for the Thai design education. Sustainable development issues are broad and vary; each country has its specific issues and/or problems based on its context (e.g. policy, environment and culture). In addition, the overall findings suggest that local relevance is required to achieve ESD. This section then draws together all findings to discuss the specific context of ESD implementation in Thailand.

7.2.1 Economic benefits are the main drivers to integrate sustainable development.

Although sustainable development requires balancing all three pillars (environment, society and economy) together, the composite findings from the literature review and interviews discovered that sustainable development in Thailand is still reliant on the economic pillar. Most of the sustainable development activities that have been actively run in the Thai manufacturing industry are mainly influenced by economic benefits. Firstly, cost reduction and/or marketing issues are the main drivers that encourage Thai companies to integrate sustainable design. Secondly, most of the government initiatives focus on enabling the participants to overcome economic challenges, as the Thai government has utilised the concept related sustainability to stimulate the national economy. The evidence for this can be seen in the initiatives and policies that were launched after the financial crisis in 1997:

- OTOP (2001) to facilitate rural Thai residents to generate a greater income through local product development.
- SEP (1997), to promote a more resilient, sustainable development, better able to conquer the challenges emerging from unpredictable changes.
- The introduction of eco-design (1999), Thailand has a strong tradition in EE since this time.

Other evidence that supports the research results that economic benefits are the main drivers for implementing sustainability in Thailand, is the significant progress of integrating environmental sustainability in the engineering field. Both business and government sectors have actively contributed to this due to the business demand from international markets. The Ministry of Commerce (Ministry of Commerce, 2014) disclosed that engineering products were in the top ten list of Thai exports. Automotive and computer parts industries have occupied the first two positions for since 2004 and earned over 28 billion GBP[7] in 2014. The interviews with participants from the government also reveal that the Thai government aims to support Thai companies to integrate eco-design to comply with the environmental regulation of the overseas market. The evidence that shows the significant progress of eco-design

[7] 1 GBP = 48.374 THB (20 Mar 2014)

implementation in the engineering field are the establishment of online networks (TGDN, and Thai Rohs) and specific organisations (XCEP, LCA Lab) (see Section 2.7.1.1).

While many activities have been carried out in the field of engineering, only slow progress has been made in the field of design. No online network for sustainable design and/or eco-design has been specifically developed for industrial/product designers. Moreover, there is no government agency that is specifically for sustainable design. TCDC is considered as a lead agency for integrating design but the findings from interviews found that little sustainable design support is provided.

7.2.2 A lack of drive and demand for ESD implementation

As illustrated in the previous section, Thai manufacturing is required to integrate environmental sustainability (or eco-design) to comply with international market regulations. The government has also supported the implementation through establishing government agencies that are directly responsible for eco-design. The literature review also demonstrated that Thailand has a strong tradition in EE. For example, the Thai LCA network has been established since 2001. Two well-known universities (KU and AIT) have also started teaching LCA in the same year. The findings concluded that engineering is the most active field in learning and teaching concept related to sustainability (eco-design) due to the drive and demand from government and business sectors (see Section 7.2.3). The findings also discovered that ESD has also been implemented in the industrial/product design education due to its business advantages such as cost reduction, and use as a selling point. Most of the participants (lecturers) agreed that they have started to teach sustainable design and/or eco-design as they are one of the current trends in the product design industry.

While a significant progress in implementing ESD has been made in the engineering field, the findings indicated the lack of drive and demand for implementing ESD in industrial/product design education. ESD is quite challenged because it is different from the traditional education approaches that are widely employed in the Thai HE system. Drive from the government and demand from the business sector are then

required for the change. Firstly, the interviews found that Thai companies do not expect new graduate designers to have sustainable design capability as they believe that it can be learnt through working experience. Secondly, the composite findings show that the government only provides little support to the implementation of ESD in HE. The interview with government officers revealed that the government is focused on integrating sustainable design into the business sector and provides less support to the education sector due to financial constraints.

To sum up, Section 7.2 demonstrates that economic benefits are key drivers that influence the integration of both sustainable development and ESD in Thailand. Engineering is the most active discipline in both the manufacturing industry and HE as there is a demand from the business sector. The Thai government also intends to support the business sector to stimulate the national economy by providing support as reflected through the launch of agencies that are responsible for the integration of eco-design. The section also indicates the lack of drive and demand from government and business sector to integrate ESD into Thai industrial/product design education.

7.3 Barriers that obstruct ESD implementation

This section satisfies objective no. 3 (see Section 1.2) by identifying obstacles that limit the integration of ESD into Thai industrial/product design education. Section 7.2 indicates the lack of drive and demand to integrate ESD. Sustainable design learning has a lower priority than other design topics, such as functional, emotional, and aesthetic design. The overall findings identified that the low priority of sustainable design is a root cause of the barriers to implement ESD into design education and how this slows down the implementation of ESD in Thai design education.

Learning channels are limited: the literature review showed that sustainable design could be taught through the various channels; specific courses and/or modules, self-learning, and discussion in other design modules. The overall findings conclude that teaching of sustainable design in other design modules is the most widespread in Thai design education as others channels are limited. Firstly, there is no sustainable product design course in Thailand. Secondly, the findings show that specific modules

for sustainable design are offered but they are only available on a few industrial/product design courses (see Chapter 4). Thirdly, a self-learning channel is limited by the lack of appropriate materials (see Section 4.4.2.3). These channels are limited due to four common barriers: perceived irrelevance by academic staff, lack of staff awareness and expertise, crowded curricula, and lack of institutional drive and commitment (see Section 2.5). Teaching through other design modules is widespread as it is directly influenced by lecturers, who are responsible for selecting the learning content. The interviews with design lecturers found that sustainable design is taught on other design modules as it is one of the current market trends. Although the channel provides students opportunities to acquire sustainable design knowledge, only a little time is dedicated to teach sustainability as it is not the main focus of the modules.

Barriers to personal development of lecturers: the previous discussion demonstrates that lecturers are the main contributors to integrate ESD into industrial/product design education. The findings showed that concepts related to sustainable development (OTOP, green design, and eco-design) have been widely discussed in the Thai design education. However, only a little progress has been made as reflected through the findings from interviews with industrial experts, which reveal that many designers do not have an insight into sustainable design; they only attempt to address a single issue and create more environmental problems. According to the findings, the progress in implementing ESD in design education has been slow due to the lack of lecturers with ESD qualifications. Most Thai lecturers are in the levels of novice and advanced beginner. Although they have a high potential to extend their sustainable design knowledge and ESD, there is a low priority and little time is provided for learning the topic (see Chapter 4). Professional development is a convenient way to update and develop pedagogical skills but the findings show that there is lack of ESD training in Thai design education. Self-development is another way to improve the ESD skills. A limited number of materials are available but most of them were not specifically developed for Thai industrial/product design lecturers so are not widely used as they require too much time and effort.

7.4 Framework development

The section discusses the findings related to the framework development. It starts by illustrating how the framework development was processed (Section 7.4.1) and specifically developed for the Thai industrial/product design education context, unlike existing ESD materials. Section 7.4.2 show the distinctive position of the framework by the comparison with other materials. Section 7.4.3 clarifies the difference through introducing the specific functions and features of the new material.

7.4.1 Overview of the framework development

This discussion shows how decisions were made during the process of the framework development starting from the data collection (literature review and interviews). The findings then enabled the researcher to identify the context of use as illustrated below:

Situation: as discussed in Section 7.3, the channels to transfer sustainable design knowledge are limited. The current level of drive and demand is not able to influence any massive changes or encourage people in the design field to carry out any specific activities to integrate ESD. The findings show that the Thai institutions do not have any intentions to introduce new sustainable product design courses in the near future. Moreover, sustainable design modules were only available in a limited number due to the lack of lecturers with ESD qualifications. Consequently, this study then selected the most active channel (learning in other design modules) to enhance the ESD implementation.

Target users: defining the target users is really important because ease of use is required to achieve the implementation of the new framework. The findings found that existing materials have not been widely used in Thai design education as they required too much time and effort. Only limited time is dedicated for learning and teaching of sustainable design due to the lack of drive and demand. Identifying a group of specific target users enables the framework to be modified to fully satisfy users' needs. The precise user profile also allows the new framework to be easy to use as it was construct based on the previous experience of the users. The overall

findings identified that Thai lecturers are the main contributors to ESD implementation. The findings also classified the contributors into five groups based on their level of ESD knowledge, the majority are in the novice and advanced beginner groups, and have taught topics related to sustainability but were not able to fully contribute to sustainable design teaching due to the lack of ESD qualification. They were then considered as the main target users of the framework.

Solution: as discussed in Section 7.3, self-development of the target lecturers is obstructed due to the lack of appropriate material that is easy to use. The framework was then constructed to comply with the target users' needs and also facilitate them to expand their ESD knowledge. The findings presented in Chapter 4 found that the target lecturers have employed some appropriate strategies in their classes but they were not constructed systematically. The findings highlight that most of the targets were not aware of the education reorientation for ESD and teach sustainable design based on their own experience. A set of basic theories were combined and presented through a diagram to enable the users to perceive an overview of ESD and be more systematic in constructing their classes. Moreover, the web tool was developed to disseminate the framework and fulfil the target lecturers. The overall findings reveal that the design lecturers also have a similar learning culture to designers as most of them have obtained design degrees. They prefer to acquire information through creative materials that maximise the use of graphics. In addition, the web tool also includes an information section that conveniently allows the lecturers to expand their sustainable design knowledge. ESD aims to reorient the existing education system (both contents and methods) to be more compatible with sustainable development. The findings obtained indicate that the targets also need support for teaching and learning content.

7.4.2 Comparison with other approaches

Some learning materials were available in the Thai HE but they were not widely employed. The research shows Thai design lecturers felt uncomfortable and struggled to utilise the existing materials because they were not specific to industrial/product design lecturers (see Chapter 4). The new framework was then tailored to fit the Thai product design lecturers' needs and make it easy to use to

enable the target users to gain complete ESD qualifications discussed in Section 7.2.2. The specific contexts and the requirements from lecturers have made the material different from other material available. The Venn diagram in Figure 42 was employed to compare the position of the developed framework with other existing materials. In this thesis, the learning materials involved all resources that propose to enable users to gain understanding (e.g. framework, web-tool, and guideline).

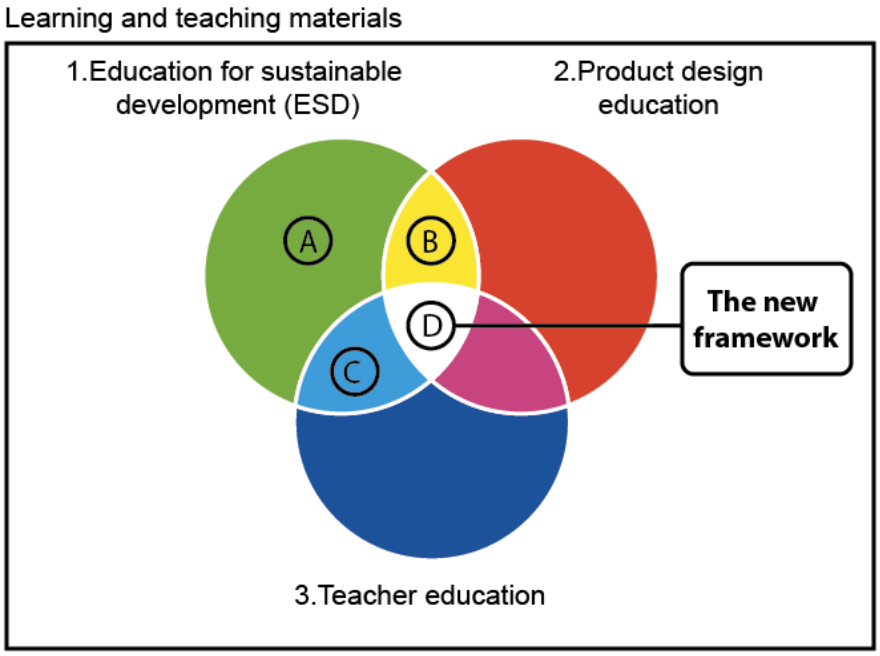


Figure 42: Comparing the positions of the new framework and other learning materials

As seen in Figure 42, the diagram consists of three sets that represent learning materials in different areas: (1) ESD, (2) design education, and (3) teacher education. All ESD learning materials are in the first set which is divided into 4 parts as discussed below:

Group A: involves all materials that propose to support the knowledge transfer of sustainable development but it does not include the learning materials that focus on teacher or design education. Many materials from this group have the potential to enable Thai product design lecturers to gain a basic understanding of sustainable development. However, they can only raise the awareness of sustainability issues as the integration of sustainable development requires more specific and detailed information. Moreover, the presentation style of materials in this group does not

comply with the learning culture of product design lecturers that was discussed in Section 2.5.2.2.

Group B: The learning materials in this group are the intersection between ESD (1) and product design education (2). Most materials in this group are specifically developed for people in the field of product design and aim to contribute to the learning and teaching of sustainable development by narrowing it down to sustainable design. For example, Information/Inspiration contains specific information that enables users to gain an understanding of sustainable design principles (Bhamra and Lofthouse, 2003). This group also includes eco-design materials, such as the Eco-design web and Design Abacus that are specific to designers.

Group C: learning materials in this group are in-between ESD (1) and teacher education (2). The materials consider lecturers as the main target users and focus on an ESD teaching approach. They contribute to ESD implementation through enhancing the capability of both pre-service and in-service lecturers. For example, the CSCT (curriculum, sustainable development, competences, teacher training) project has introduced a curriculum model to facilitate the training of pre-service lecturers (CSCT, 2008). Although they were developed for lecturers, most did not utilise them because they felt uncomfortable with the relatively complex information as lecturers have received degrees relating to design not education.

Group D: The developed framework is categorised in group D that is the intersection of all three sets. It has all the advantages of materials in group B and group C. According to the overall findings, materials in group D were not available in product design education. The findings from the literature review (Chapter 2) and empirical studies (Chapter 4) showed that most of the existing materials were in groups B or C. The feedback from the framework evaluation (Chapter 6) also confirmed that there have been no ESD materials developed that are specific to product design courses.

7.4.3 Specific feature of the material

As discussed in the previous section, the framework is more specific than other materials as the target users are within three different disciplines: ESD, product

design education, and teacher education. The distinctive needs of Thai industrial/product design lecturers made the material have specific functions and features.

7.4.3.1 Emerge of a new function for ESD learning material

According to Chapter 2, each set of ESD material was developed based on its specific aims and objectives that can be grouped into two major goals: raising awareness of sustainable development and facilitating the implementation of the concept. The study also found that the major goals are directly associated with the functions of the learning materials as presented in Figure 43. This section discusses how existing materials facilitate lecturers to teach sustainable design. These functions can be divided into two groups based on the major goals. At the end of the section a new function that emerged during the framework evaluation is introduced.

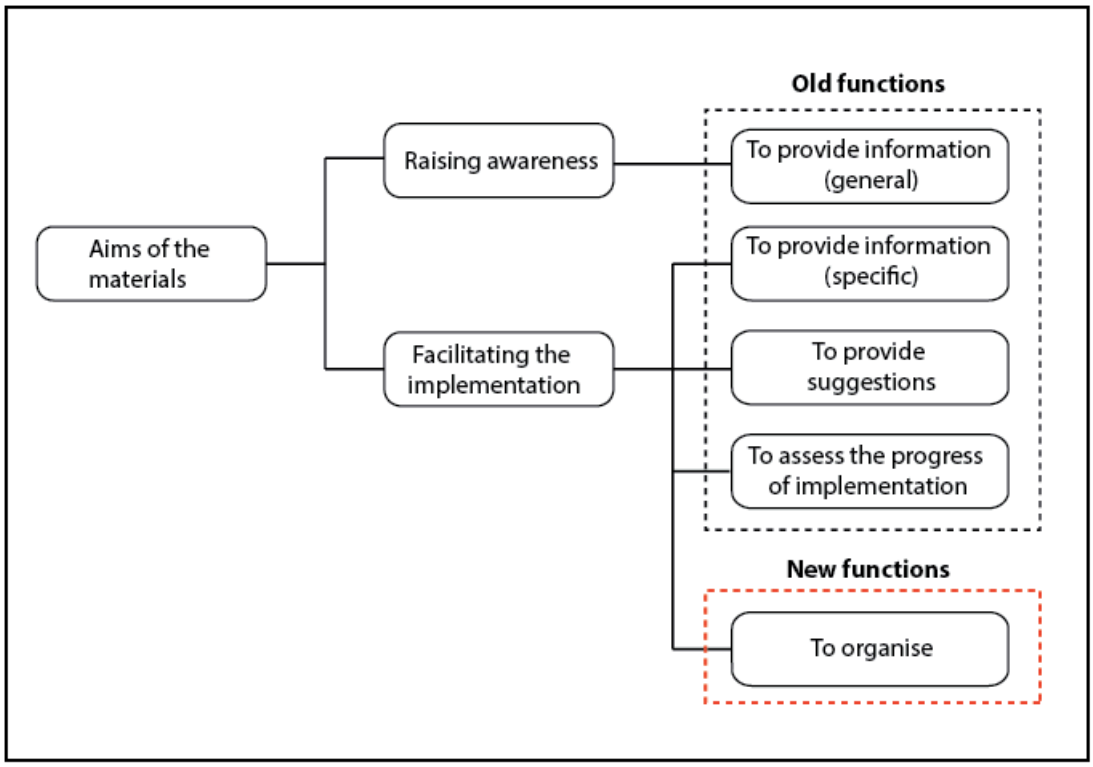


Figure 43: Functions of ESD learning materials

As shown in Figure 43, the first group is the materials that mainly focus on raising awareness of sustainable development. The materials in this group only provide

general information that is easy to understand because the target audiences are beginners and they might not be familiar with the concept. For example, the documentary film called “An Inconvenient Truth” was initially launched to raise awareness of global warming in the United States. Although the materials in this group enable users to gain some basic understanding of sustainability issues, they cannot facilitate the integration of sustainable development into their disciplines due to the complexity and diversity of doing so.

Materials in the second group aims to facilitate the target users to integrate sustainable development into their disciplines. The materials in this group are more specific than the first group. They were usually developed to satisfy a specific group of users. They are often utilised to support the implementation through three main functions as discussed in the next page:

- To provide information: This function is similar to the materials in the raising awareness group but the information provided is more specific and complex. Chapters 2 and 4 showed that the implementation of sustainable development is diverse. Some disciplines require a particular set of information to integrate sustainable development. For example, Information/Inspiration (Lofthouse, 2006) offers sustainable design principles and some design case studies to inspire designers to integrate the concept into their design.
- To suggest the solutions: this function is slightly different from the previous one. Instead of specific information, step-by-step guidelines to integrate sustainable development are provided. For example, the “Design for sustainability (D4S) manual” emerged from the cooperation between UNEP and Delft University (Crul and Diehl, 2006). The D4S aims to facilitate SMEs in developing economies to integrate sustainable design through providing solutions that are presented through a step-by-step manual.
- To assess the progress of the implementation of sustainability issues: assessment is important because it can guide the direction of the implementation of any stages. For example, Life Cycle Assessment (LCA) enables engineers to compare eco-products through calculating people’s

carbon footprint. Another example is the "Unit-based sustainability assessment tool" developed by UNEP (Togo and Lotz-Sisitka, 2009). It can be used to assess the progress of implementation in HEIs.

The new framework is also categorised in the second group as it aims to facilitate the integration of ESD into product design courses. It initially intends to support the target users through the first two functions: providing specific information, and suggesting an appropriate teaching approach. The framework evaluation (Chapter 6) showed that the framework can support the lecturers through the expected functions. In addition, many of the participants in the target user group considered it as an organising framework. Section 6.4.7 found that the participants tried to link their existing activities with the framework while they were using it.

7.4.3.2 Providing breadth information rather than depth information

The way to present information is another element that distinguishes the new framework from other materials in the same categories. Existing materials (Section 2.5) normally provide in-depth and very detailed information that enables beginners to build knowledge step-by-step. For example, D4S provides detailed instructions to enable SMEs to integrate sustainable design into their product development from the first step. However, the developed framework was specifically developed for the Thai industrial/product design lecturers in the novice and advanced beginner groups (Section 5.2). Section 4.4 described how lecturers already have experience of some ESD teaching. They are only required to gain a holistic view of ESD that enables them to be more competent in ESD teaching. Section 4.5.2.4 found that the lecturers have already employed some appropriate teaching activities but they did not organise them systematically. The framework then offers a wider scope of information that enables them to holistically view ESD and systematically organise their ESD activities.

Moreover, the information part expands the range of knowledge and makes the framework more effective. It was initially included in the *SustainAble* web-tool as one of the elements employed for the framework evaluation. However, Chapter 6 found that the information part is required for an effective implementation of the framework due to it benefits discussed in Section 6.5.1. This combination

(framework and information part) provides a wider scope of information and enables the framework to have better potential to be successful in implementation. The framework evaluation (Chapter 6) revealed that the participants frequently consider the *SustainAble* web-tool (both framework and information part) as a one-stop material that is compact and contains the inclusive information required for ESD teaching.

7.5 Keys to success

The findings from Chapter 6 demonstrate the success of the developed framework and the web-tool and show that most of the participants in the lecturers' group appreciated the developed framework and web-tool. Some of them showed the intention to use the materials and asked for the publishing date. The keys to success of the framework development are identified in this section.

7.5.1 The framework is easy to understand

According to the findings from the literature review (Chapter 2) and interviews (Chapter 4), most of the Thai product design lecturers do not employ the existing materials as they require a lot of time and effort to understand and lecturers only dedicate a little time to developing their ESD skills due to the lack of drive and demand discussed in Section 7.2.1. Thus, ease of use is a prerequisite requirement for the development of appropriate material. The framework evaluation (Chapter 6) showed that most of the participants of target users' group were able to understand most of the framework elements. Moreover, the developed framework is presented through the web-tool that can comply with the learning culture of designers. Designers prefer to acquire knowledge through materials that have a full use of graphics. While TQF presents its contents through a text format, the new framework utilises graphic design to convey the information (see Chapter 5). In addition, the framework information was divided into short pieces of content that are easier to read and avoid being overwhelming.

7.5.2 No increase to workload

The findings from Chapter 4 show that existing materials have not been widely applied in Thai design education as it increases the lecturers' workload. The

implementation of TQF was the most significant example. TQF also relies on a competence-based approach that is compatible with ESD. It can be used to facilitate the learning and teaching through self-reflection and lecturers can utilise it to reorganise their teaching activities. Although the Thai government has tasked all lecturers in HEIs to adopt the assessment framework, the implementation was not successful because they have to complete a number of forms. The new framework is more appropriate as it does not increase their workload. Moreover, Chapter 6 found that some lecturers mentioned that they will utilise the information part or case studies provided for their teaching preparation.

7.5.3 Building on existing ESD activities

Cooperation is required to ensure the successful integration of sustainable development. Although some related initiatives have been launched, they have not been able to create any significant impacts. Many Thai companies still design products that contribute to unsustainable lifestyles and create many negative impacts on the environment and society. The findings from Chapter 4 revealed that the existing initiatives would have better outcomes if they were connected to each other.

The findings from Chapter 6 shows that the framework has potential to be more effective than other materials because it builds upon existing ESD activities and links them together. Firstly, the framework focuses on developing the skills of in-service lecturers that have gained both sustainable design and teaching experiences it involves, thus enhancing the performance of in-service lecturers instead of educating pre-service lecturers that have less experience. Secondly, it is associated with the TQF that has currently been adopted in Thai HE. Chapter 2 found that the new framework and TQF rely on a competence-based approach that is compatible with the ESD so this similarity benefits both. Chapter 4 reveals that many lecturers did not understand the TQF. Section 6.4.4 found that the new framework enables them to have a better understanding of the TQF. In turn, the TQF encourages the lecturers to use the new framework (see Chapter 6).

7.5.4 The framework is related to the routine activities

As concluded in the previous Section 7.2.1, the drive and demand has not influenced the lecturers to change their routine activities and dedicate more time in developing ESD skills. Chapter 4 found that the Thai lecturers usually use the internet to acquire new information and prepare their teaching content. The framework is disseminated through a web-tool and only requires a little time, as it is easy to understand (see Section 7.5.1). Moreover, it does not require the users to change their teaching activities. It helps them to be more organised and lets them know what sustainable design competences can be engaged through their existing activities.

7.6 Potential of the framework in the reality

The findings from interviews (Chapter 4) disclosed that implementing ESD was not considered as a priority in the Thai industrial/product design education. The Thai design lecturers only dedicate a limited amount of time and effort in teaching sustainable design. The low priority issue obstructed lecturers from gaining a better understanding of ESD and sustainable design. The research found that existing materials were not widely utilised as they require a lot of time and effort. For example, most of the local materials were developed based on engineering; they contain lot of complex terms and equations that are too complicated for the design lecturers. Consequently, ease of use was considered as part of the design criteria presented in Chapter 5. The framework was then built based on the context of Thai industrial/product design education.

The findings from Chapter 6 showed that the framework can be considered as an easy starting point for acquiring an ESD qualification. The participants only required a small amount of time to understand the framework due to the inclusion of the keys to success presented in Section 7.5. The evaluation (Chapter 6) confirmed that the web tool (Sustainable Info and framework sections) successfully achieves its aim in enabling the target lecturers to develop their ESD qualification. The findings demonstrated that the participants have gained better understanding in ESD and sustainable design since experiencing the web tool (both framework and information sections). It allowed the lecturers (participants) to map their previous experience and think more systematically. The findings also showed that the framework has

potential to be widely utilised in Thai industrial/product design education due to its ease of use. However, the findings also showed that the framework might not be able to fully influence the lecturers to reinforce the ideology of ESD. ESD should facilitate students to acquire knowledge, skill, and values inherent in sustainable development. During the evaluation stage, most of the participants gave little focus to issues related to the affective domain that is associated with incorporating values.

In addition, the discussion is constructed with the intention to satisfy the research objective presented in Section 1.2. Chapter 8 will demonstrate how the research objectives are satisfied.

Chapter 8: Conclusions and future work

This chapter draws all the research findings together to provide an overall conclusion to the study through five sections: Section 8.1 demonstrates that the research aims and the objectives have been fulfilled; Section 8.2 summarises all findings which emerged from this study; Section 8.3 discusses the limitations of the research; Section 8.4 identifies the contribution to knowledge; and Section 8.5 gives recommendations for future work.

8.1 Meeting research aim and objectives

The overall aim of the doctoral research was to propose a methodological framework to contribute to ESD implementation in undergraduate industrial/product design courses in Thai HE. The research aim was broken down into five objectives presented in Section 1.2. The research activities were then carried out to achieve the objectives. The discussions presented in Chapter 7 are referred to illustrate how the objectives were achieved.

Table 41: Satisfying the research objectives

No.	Objective	Section
1	To critically review the literature and secondary data relating to: • The relationship between sustainable development and the design profession • ESD • ESD learning materials or mechanisms related to industrial/product design education	7.1
2	To explore and understand the Thai context: • The implementation of sustainable development in Thailand • The existing sustainable development activities • The implementation of ESD in Thai HE (especially in industrial/product design courses)	7.2
3	To investigate (explore and describe) sustainable design modules that are available in Thai HE by focusing on product/industrial design courses: • To identify obstacles that limit the knowledge extension of sustainable design • To evaluate teaching and learning techniques that are currently employed	7.3
4	To develop more appropriate learning material that can effectively contribute to the implementation of ESD in the Thai product design education: • To identify the target users • To identify the criteria to develop the framework • To identify the solution to disseminate the framework	7.4
5	To evaluate the developed framework by collecting feedback from design lecturers	7.5 7.6

As seen in Table 41, all objectives were satisfied through the activities presented through the five chapters. The details are discussed in the following paragraphs:

Objective 1 was addressed through the literature review (Chapter 2). It explored the theories and information required for the development of the ESD teaching framework. The required information included the basic theories related to sustainable design, appropriate ESD learning approaches, barriers to implementing ESD into HE, and existing ESD materials. Moreover, Section 7.1 also fulfilled the objective through elaborating the relationship between industrial/product designers and sustainable development. Although it identified that the output approach is a more appropriate way for ESD, the traditional approach is still required in some cases. The role of lecturers is also emphasised in the discussion. They are expected to select, combine, and construct sustainable design classes that are appropriate to the specific context of each group of learners.

Objective 2 was partly fulfilled by the findings from Chapter 2. The literature review identified that investigating the Thai context is a prerequisite requirement to the successful development of the framework. Some information related to the Thai context was available through related publications and grey literature. However, there was a lack of information relating to the integration of sustainable design into the Thai manufacturing industry and ESD implementation in Thai HE. The interviews with experts from different fields were then carried out to fulfil objective 2. Next, Section 7.2 draws these findings together and discovered that sustainable development and ESD implementation in Thailand is mainly influenced by economic benefits. Engineering is the most active discipline in both education and business sectors due to the pressure from the overseas market. Thai companies are required to comply with the environmental regulations to trade products overseas. Although significant progress has been made in the engineering field, the discussion found the lack of drive and demand to implement sustainable design and ESD in the design field.

Objective 3 also proposed to investigate the Thai context but it was scoped down to the learning and teaching of sustainable design in Thai industrial/product design

education. The objective was satisfied through in-depth interviews with Thai industrial/product design lecturers. The interviews (findings presented in Chapter 4) discovered the current state of ESD implementation in Thai design education. Existing learning activities and barriers to teaching sustainable design were explored. The discussion in Section 7.3 brought all the findings together and identified two major obstructions that emerged from the low priority of sustainable design; (1) knowledge dissemination channels are limited and (2) barriers to personal development of lecturers.

Objective 4 was to develop more appropriate learning material that contributes to the ESD implementation in Thai industrial/product design education. This objective was achieved in Chapter 5, the findings obtained from the literature review (Chapter 2) and empirical studies (Chapter 4) were utilised in the processes of framework development including identifying the target users, design criteria, and framework design. In addition, the *SustainAble* web-tool was developed to satisfy a part of the objective that proposed to find the appropriate solution to disseminate the framework. Section 7.4 satisfied the objective through providing an overview of how decisions were made during the development process. It also presents the specific characteristic of the new framework and web tool.

Objective 5 was realised by conducting framework evaluation. The lecturers mentioned in Chapter 4 were invited to participate in the usability testing of the web tool (both framework and 'Sustainable Info' sections). The evaluation demonstrated the successful development and showed that the framework together with the 'Sustainable Info' section were able to satisfy the overall aim of the PhD study. Chapter 7 drew the findings together and identified the keys to success of the framework development (Section 7.5) and also presented the potential of the new material (Section 7.6).

8.2 Conclusions/key findings

Education is considered as an important element to integrate sustainable design because it equips future designers or decision makers with knowledge, skills and values required for sustainable development. However, the curricular review

(Chapter 4) unveiled that there was a lack of sustainable design learning and teaching in Thai industrial/product design education. The PhD research aimed to contribute to sustainable product development in the Thai manufacturing industry through supporting the implementation of ESD in Thai industrial/product design courses. The literature review found that appropriate learning materials potentially support the implementation of ESD through facilitating self-learning. However,, Chapter 4 found that the existing materials were not widely utilised as they require a lot of time and effort to understand. This research was then conducted to address the issues and contribute to the ESD implementation in Thai HE.

At a theoretical level, this research study addressed the shortage of information related to the Thai context (as discussed in the Chapter 2). An empirical study (Chapter 4) was carried out to investigate the current state of implementing sustainable design in both the Thai HE system and industry. The findings obtained were then utilised to tailor a framework to fit Thai industrial/product design courses. Table 42 presents the specific situations and problems that were drawn from the findings. It also suggests solutions to address these problems.

Table 42: Specific problems in Thai HE system and problem solving solutions

	The specific problems	Problem solving solutions
1	The lack of sustainable design courses and modules.	To consider the lecturers as target users
2	The lack of government drive and business demand.	To develop a framework that is easy to understand and requires a short period of time to gain inclusive information.
3	The current teaching activities cannot fully contribute to the integration of sustainable design in the industry.	To identify and offer a more appropriate teaching approach
4	The target lecturers were lacking in a holistic view of sustainable design.	To offer a set of basic principles that allow them to gain a holistic view

These four problems are discussed in more details in the paragraphs below:

The first context was the lack of related courses and modules. This situation limited learning opportunities for Thai design students. The lecturers can influence ESD as

they play a role in selecting learning topics. Chapter 4 showed that Thai design lecturers have started to discuss sustainable design in their classes as it is considered as a marketing trend. However, many were not able to fully facilitate the learning and teaching of sustainable design because of their lack of complete ESD qualifications. Moreover, some of them also confused their students through providing unclear explanations (Section 7.2.2). The PhD study then proposed to enhance the capabilities of in-service lecturers who can be divided into five groups based on their ESD knowledge (see Section 4.3). The study only focuses on novice and advanced beginner levels because they were the majority of the Thai design lecturers and were required to fulfil their ESD qualification.

The second context was the lack of drive from the government and business sector. This can be considered as the root cause of the shortage of lecturers with ESD qualifications. Chapter 4 shows that the target lecturers have potential to improve their ESD capability and become proficient (and effectively facilitate ESD learning). However, the lack of drive led them to give ESD a lower priority and only provide limited attention and time to gain ESD information. Although existing ESD materials were available online, they were not widely used as they were time-consuming and too complex for design lecturers. Ease of use was then considered as one of the criteria of the framework development.

Thirdly, the existing teaching activities were not able to effectively contribute to the integration of sustainable development. This root cause was the lack of insight into ESD teaching theories that was discussed in Chapter 4. Many Thai lecturers have never obtained a degree in education and only teach based on their previous experience. They have adopted and applied some appropriate learning strategies such as service learning and problem based learning. But they could not effectively use them owing to unsystematic teaching planning (Section 4.4.2.5). Although the findings revealed that the target lecturers have potential to gain complete ESD qualifications, they were obstructed by the lack of appropriate materials (Section 4.4.2.3) and professional development training. In the developed framework, the related principles were selected and presented together in one place. Firstly, a set of six competencies that was developed from the work of Wiek et al. (2011) was

selected because it presents competencies through a format of problem solving solutions. Section 5.4.1 showed that the problem-solving format is compatible as it is associated with the logic that has been used to teach industrial/product design students. Secondly, Sipos et al's (2008) set of learning domains adapted from the Bloom taxonomy (1965) was included in the new framework as ESD learning required a profound change in behaviour. These learning domains not only focus on engaging students through the cognitive and psychomotor domains they also focus on the affective domain that can reinforce behavioural change. These two theories were then combined and modified to make them more suitable for the lecturers as discussed in Section 5.4.

The last context is Thai lecturers did not have a clear view of sustainable design. Although they have gained some experience related to sustainability through the previous trends: eco-design and OTOP, they did not link them together and could not clearly discuss sustainability issues. Chapter 4 found that most of the participants in the novice and advanced beginner levels discuss sustainability issues by predominantly focusing on either social or environmental aspects but not both. As discussed in Section 2.3.2, ESD aims to reorient the existing education system (both method and content) to be more compatible with sustainable development. The PhD study initially focused on the teaching approach (method). However, the lack of clear view of sustainable design was considered as one of the barriers to implementing ESD in Thai industrial/design education (Section 4.4.2.1). For example, the target lecturers might confuse students though providing unclear explanations. The study resolved this problem through introducing the 'Sustainable Info' section. It contains a set of basic principles that allow the target lecturers to map their previous experience and broaden their sustainable design knowledge.

Practicality, the framework evaluation (Chapter 6) demonstrated the successful development of the framework. It confirms that the recommendations in Table 42 can resolve the problems and contribute to the ESD implementation. The usability testing was employed to assess the satisfaction of the target users. Seventeen lecturers were invited to test the framework that presented through the web-tool prototype. The feedback from the participants in both (ten participants and seven

experts) underlined the need to present the framework together with its complementary element (Sustainable Info section). Along with its direct advantage in enabling the lecturers to expand their sustainable design knowledge, the findings also showed that the information section also influenced the lecturers to utilise the web tool and experience the framework section. Most of the participants appreciated the information provided and have asked for its website URL. They also revealed that the framework can facilitate them in teaching preparation.

8.3 Limitations of the research

This section reflects on the limitations of the research study that arose during the framework development. The time and resource constraints were the root cause of the limitations discussed in these following sections. In addition, the discussions also shed the light on the further work recommended, in Section 8.5.

Variety of opinions: the PhD study centred on gaining the lecturers' perspectives even though the ESD activities are based on work with other stakeholders: industrial/product design students and business sector. The Thai product design companies are also relevant to the ESD learning activities as they can assess the performance of new design graduates. Consequently, obtaining opinions from these two groups would have been beneficial to the research. However, the researcher was based in the UK and had limited time for the field study. Additional data collection was not carried out in the PhD study.

Uncompleted usability testing: usability testing was employed as the framework will be disseminated through a web-tool called "SustainAble". The testing method provided opportunities to observe the participants while they were using the web prototype, and collect feedback through semi-structured interviews. The findings obtained from these empirical studies were able to satisfy the research aim in evaluating the effectiveness of the framework and web tool. However, the data collection process would have been more rigorous and provided more detailed information if it had followed the suggestions below:

- Employing more staff members to complete the number of tasks required to be carried out at the same time during the usability testing. The researcher

played roles in moderating, recording and observing. More staff members were required so the researcher could have focused more on the observer role. Some interesting issues (participants' reactions) that emerged during the test could have been missed.

- Using screen and video recorders to capture participants' actions during the test and review them later would have allowed the participants' actions to be captured. However, the empirical study only recorded participants' voices due to the lack of appropriated devices and software prototype.

Framework feedback from the real implementation: in the framework evaluation (chapter 6), usability testing was employed to collect the participants' feedback after experiencing the framework and the *Sustainable* web-tool. The feedback could satisfy the research study through assessing users' satisfaction with the effectiveness of the materials. However, the framework and the web-tool has still not been fully implemented into Thai industrial/product design courses. The study found that the results from the real practices potentially provided advantages for refining the framework in the future. For example, an expert (UNI-5-1-P) recommended that a case study of the framework implementation can help lecturers to have a better understanding of the framework elements. Few were confident in the approach and asked for an example of a successful case study. Another possible advantage is it can encourage lecturers to apply the framework.

8.4 Contribution to knowledge

This PhD research was proposed to support ESD implementation in product design education through the development of a new ESD framework. Similar to other previous research projects (Victoria-Uribe, 2008; Lofthouse, 2006; Crul and Deihl, 2006), the framework development also underlines the need to tailor ESD materials because the specific learning materials or mechanisms can provide more effective knowledge transfer. For example, Chapter 4 found that most of the existing Thai materials were not widely applied in the Thai industrial/product design education context as they were not specific to people in the field of design and did not comply with the learning culture. The findings from this research study are novel and

different from previous works because they focused on the Thai industrial/product design education that has very specific contexts. The doctoral research was one of the very few research projects that have been specific to the implementation of ESD in Thai industrial/product design courses. The literature review (Chapter 2) showed the lack of information related to ESD implementation in the Thai HE and identified the need for this research project. The uniqueness of the Thai context also led the framework being unique, as presented in Section 7.3 and Section 7.4.

The first and foremost contribution of this study is the web tool that includes both the new theoretical framework and its complementary element. It can be directly adopted into the Thai industrial/product design education and facilitate design lecturers to gain their ESD qualification. Secondly, the findings that emerged from the development processes (literature review, data collection, framework development and evaluation) can also facilitate other ESD initiatives in Thai design education. As discussed in Section 5.2, the study only developed a framework for design lecturers, Thai industrial/product design education still requires more support and still lacks materials in other areas, such as assessment tools and specific materials for design students.

Along with the direct contributions, the problem-solving solutions that emerged in this study can be applied in other learning disciplines or other countries that face similar barriers. According to the literature review (Chapter 2), the member countries of ASEAN risk facing similar problems because their ESD implementation also started from EE. Moreover, OVOP (or OTOP in Thailand) has been widely implemented in other member states such as Cambodia, Laos, and Myanmar (ASEAN, 2014).

8.5 Recommendation for further work

The PhD project filled the gap regarding the lack of appropriate ESD materials for the Thai industrial/product design education through the framework development. A theoretical framework and *SustainAble* web-tool were developed. Moreover, the findings that emerged in the research study allow educators to develop other materials that focus on Thai design education. Although the research fulfilled its aim

and objectives, further studies are required to promote ESD implementation in Thai industrial/product design education. Recommendations for further work are listed below:

- To implement the developed framework and the web tool in the Thai industrial/product design context and carry out additional data collection to acquire opinions of design students and design companies. This will be useful for refining the framework and the development of other materials as these two groups are also associated with ESD learning activities.
- To identify the mechanism to promote ESD materials. This research identifies the internet as the most appropriate distribution channel due to its advantages, such as cost-saving and providing interactive functions. However, users still need to be aware of the materials before accessing them.
- To develop ESD materials for Thai design students, some experts and some participants agreed that the information part can facilitate the self-learning of the Thai industrial/product design students. Thus, it can be used as a base to develop an information provision tool for Thai design students.
- To acquire more Thai case studies. As discussed in Section 6.6, stakeholders (lecturers and students) in the design field prefer to acquire knowledge through design case studies. But most of the ones available are based on other countries that have different contexts.
- To give more focus to usability of the web design; both user experience (UX) and user interface (UI). In this PhD research, the focus was given to the development of the new framework. It only employed a part of the usability processes to assess the effectiveness of the framework and tool. Carrying out further works on developing UX/UI will enable the web tool to be more effective and easier to use.

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Appendix A: The list of undergraduate industrial/product design courses in Thailand

No.	Code	Int	Degree Names	Under	Dur	Est	No.L	No.S	A&O			C O	M D	Remarks
									S	E	M			
1	002	BU	Bachelor of Fine and Applied Arts (Product Design)	Fine & Applied Arts	4	2012	n/a	n/a	-	-	-	/	/	
2	003	BKKTHON	Bachelor of Fine and Applied Arts Program in Visual Art Design –Product Design	Fine & Applied Arts	4	New	n/a	n/a	-	-	-	-	-	
3	005	KBU	Industrial design	Architecture	4	2013	n/a	n/a	n/a			/	-	
4	006	KKU	Bachelor of Architecture (Industrial Design)	Architecture	5	2005	7	n/a	/	/	/	/	-	Emphasis on SS
5	007	CU	Bachelor of Industrial Design	Architecture	5/4	n/a	n/a	n/a	-	-	-	/	/	
6	009	CMU	Bachelor of Fine Arts Programme in Design	Fine Arts	4	n/a	n/a	n/a	n/a			/	/	
7	011	TSU	Bachelor of Fine and Applied Arts (Design)	Fine & Applied Arts	4	2014			/	-	-	/	/	
8	012	KMUTT	Bachelor of Fine and Applied Arts, (Industrial Design)	Architecture and Design	5/4	2002	12	n/a	-	-	-	/	-	International Program
9	013	KMUTNB	Bachelor of Fine Arts Program in Applied Art and		4									
10	018	NU	Bachelor of Fine and Applied Arts (Product and Package Design)	Architecture	4	2008			/		/			Initially established as packaging design in 1999
11	019	BUU	Bachelor of Fine and Applied Arts (Product Design)	Fine & Applied Arts	4	2009			/					
12	025	RSU	Bachelor of Fine Arts Program in Product Design			1987			/	/	/			
13	029	WU				2009								
14	030	SWU	Bachelor of Fine and Applied Arts (Visual Design)											4 majors including product design
15	032	SU	Product design	Decorative Arts										

No.	Code	Int	Degree Names	Under	Dur	Est	No.L	No.S	A&O			C O	M D	Remarks
									S	E	M			
16	038	AU	Bachelor of Fine and Applied Arts (Product Design)	Architecture	4	2011	n/a	n/a	/			/	-	International Program
17	041	UBU	Bachelor of Fine and Applied Arts (Product Design)	Fine & Applied Arts	4	n/a	n/a	n/a	n/a			-	-	
18	043	KMITL	Bachelor of Architecture (Industrial Design)	Architecture	5/4	1977	32	n/a	-	-	-	/	/	
19	044a	RMUTT	n/a	Fine & Applied Arts	4	n/a	5		/	/	-	/	-	Faculty's A&O
20	044b	RMUTT		Fine & Applied Arts	4				/	/	-	/	–	Faculty's A&O
21	046	RMUTK	Bachelor of Technology (Industrial Product Design)	Science and Technology	4	2005	9	70	/	-	-	/	/	Social Focus: only ethic
22	047	RMUTR	n/a	Architecture & Design	4	2009	7	n/a	/	/	-	/		Faculty's A&O
23	048	RMUTP	Bachelor of Technology (Industrial Product Design)	Architecture & Design	4	n/a	15	105	/	-	-	/	/	Social Focus: Thai Wisdom + Ethic
24	049	RMUTTO	Bachelor of Architecture in Industrial Design	Engineering and Architecture	5	2003	n/a	n/a	/	-	-	-	-	Faculty's A&O
25	050	RMUTL		Arts & Architecture					/	-	-	-	-	
26	051	RMUTI		Fine Art & Industrial Design	4	2003	n/a	n/a	-	-	-	-	-	
27	056	KSU	Bachelor of Architecture (Industrial Design)	Creative Industry	4	2011	8+11	50	/	-	-	/	/	
28	059a	CRRU	Bachelor of Architecture (Innovative Design)	Industrial Technology	5	2010			/	/		/		
29	059b	CRRU	Bachelor of Art (Product Design)	Social Science	4	n/a	n/a	n/a	n/a			-	-	
30	060	CMRU	Bachelor of Science (Product Design)	Science and Technology	4	n/a			/	-	-	-	-	
31	061	CPRU	Bachelor of Science (Industrial Product Design)	Liberal arts & Science	4	n/a	n/a	n/a	/	-	-	-	-	Faculty's A&O

No.	Code	Int	Degree Names	Under	Dur	Est	No.L	No.S	A&O			CO	MD	Remarks
									S	E	M			
32	062	TRU	Bachelor of Technology (Product Design)	Industrial Technology	4	2006	n/a	n/a	/	-	-	/	-	
33	063	DRU	Bachelor of Fine Arts Program (Applied Art Design)	Humanities & Social Science	4	n/a	n/a	n/a	/	/	-	/	-	
34	066	NRRU	Bachelor of Industrial Technology Program in Industrial Design	Industrial Technology	4	n/a	n/a	n/a	/	/	/	-	-	
35	067	NSTRU	Bachelor of Science (Industrial Product Design)	Industrial Technology	4	n/a	C	n/a	n/a			-	-	
36	068a	NSRU	Bachelor of Fine Arts Program in Design	Industrial Technology	4	n/a	4	n/a	/	-	-	/	-	(Major in Industrial Product Design)/ SF:Ethic only
37	068b	NSRU	Bachelor of Fine Arts Program in Fine and Applied Arts	Humanities & Social Science	4	2006	5	30	/	/	-	/	-	
38	069	BSRU	Bachelor of Science (Industrial Product Design)	Science and Technology	4	2004	8	40+	/	-	-	/	-	
39	070	BRU	Bachelor of Science (Industrial Product Design)	Industrial Technology	4	n/a	n/a	n/a	n/a			-	-	Info retrieved from http://www.ocsc.go.th
40	071	PNRU	Bachelor of Science (Industrial Product Design)	Industrial Technology	4	n/a	n/a	n/a	n/a			-	-	Info retrieved from http://www.ocsc.go.th
41	072	ARU	Bachelor of Fine Arts (Fine & Applied Arts)	Humanities & Social Science	4	n/a	6	n/a	-	-	/	/	-	
42	073	PSRU	Bachelor of Science (Industrial Product Design)	Industrial Technology	4	n/a	n/a	n/a	n/a			-	-	Info retrieved from http://www.ocsc.go.th
43	074	PBRU	Bachelor of Art (Art & Design)	Humanities & Social Science	4	n/a	n/a	n/a	/	-	-	-	-	Info retrieved from http://www.ocsc.go.th
44	075	PCRU	Bachelor of Science (Industrial Product Design)	Science and Technology	4	n/a	n/a	n/a	n/a			-	-	Info retrieved from http://www.ocsc.go.th
45	076	PKRU	Bachelor of Technology (Product Design)	Science and Technology	4	n/a	4	50+ 25	/	-	-	/	-	2 Campuses
46	077	RMU	Bachelor of Science (Industrial Product Design)	Science and Technology	4	n/a	4	n/a	n/a			-	-	

No.	Code	Int	Degree Names	Under	Dur	Est	No.L	No.S	A&O			C O	M D	Remarks
									S	E	M			
47	80	RRU	n/a	Industrial Technology	4	1995	n/a	n/a	-	-	/	/	-	Faculty's Aim
48	84	VRU	Bachelor of Science (Industrial Product Design)	Industrial Technology	4	n/a	19+8	n/a	/	-	-	/	/	
49	85	SSKRU	Bachelor of Science (Industrial Technology)	n/a	4	n/a	n/a	n/a	n/a			-	-	(Major: Industrial Design)
50	86	SNRU	Bachelor of Science (Industrial Technology)	Industrial Technology	4	n/a	n/a	n/a	n/a			-	-	Info retrieved from http://www.dusit.ac.th
51	87	SKRU	Bachelor of Fine and Applied Arts (Design)	Fine and Applied Arts	4	n/a	8+4	60	/	/	/	/	/	
52	88	DUSIT	Bachelor of Science (Industrial Product Design)	Science and Technology	4	1992	n/a	n/a	n/a			-	-	
53	89a	SSRU	Bachelor of Science (Industrial Product Design)	Industrial Technology	4	n/a	n/a	n/a	/	-	-	-	-	
54	89b	SSRU	Bachelor of Fine and Applied Arts (Craft Product Design)	Fine and Applied Arts	4	n/a	n/a	n/a	n/a			-	-	
55	90	SRU	Bachelor of Science (Industrial Design)	Science and Technology	4	n/a	n/a	n/a	n/a			-	-	Info retrieved from http://www.mua.go.th
56	91	SRRU	Bachelor of Science (Industrial Product Design)	Industrial Technology	4	n/a	n/a	n/a	n/a			-	-	
57	93	UDRU	Bachelor of Technology (Industrial Design)	Industrial Technology	4	n/a	5	60	n/a			-	-	
58	94	URU	Bachelor of Technology Program in Product Design Technology	Industrial Technology	4	n/a	n/a	n/a	/	-	-	-	-	Faculty's Aim
59	95	UBRU	Bachelor of Science (Industrial Product Design)	Industrial Technology	4	n/a	n/a	n/a	n/a			-	-	Info retrieved from http://www.mua.go.th

Appendix B: Examples of curricular review sheets

General Information:

No./Code	1/2				
HEI's name/Established year	Bangkok University				
Course name	Bachelor of Fine and Applied Arts Program in Product Design				
Degree name	Bachelor of Fine and Applied Arts (Product Design)				
Course duration	4 Years				
Over all credits	140				
General education		Core modules		Elective modules	
Access from	http://fab.bu.ac.th				
Date of access	13/03/14				

Modules:

No	Module Names	Credit	Type	Type				Envi	Soci	Ecn	Yr	Remark
			C/E	CC/G	L	P	S					
1	Thai Citizens, Global Citizens	3	C	G	3	0	6		/		3/1	
2	Thai Wisdom and Creative Economy	3	C	G	3	0	6		/	/	4/1	
3	Value of Graduates	3	C	G	3	0	6	/	/		2/1	
4	Survey and Analysis of ASEAN Product	3	C	G	3	0	6		/			
5	Asian Culture for Service Design	3	E	CC	1	4	4		/	/	3/1	

Remarks:

-

General Information:

No./Code	10/30				
HEI's name	Srinakharinwirot Unversity				
Course name/Established year/No. of students	Bachelor of Fine and Applied Arts Program in Visual Design				
Degree name	Bachelor of Fine and Applied Arts (Visual Design)				
Course duration	4				
Over all credits	131				
General education		Core modules		Elective modules	
Access from	http://academic.swu.ac.th				
Date of access	14/03/14				

Modules:

No	Module Names	Credit	Type	Type				Envi	Soci	Ecn	Yr	Remark
			C/E	CC/G	L	P	S					
1	Human and society	3	C	G	2	2	5		/		1/1	
2	Thai wisdom for innovative design	2	C	CC	2	0	4		/		1/1	
3	Arts for society	3	C	CC	3	0	6		/		1/2	

Remarks:

- Got 4 majors: Product design, communication design, Jewelry design, and Communication design
- No modules' details
- Module names were only available in Thai

General Information:

No./Code	--/043				
HEI's name	(KMITL)				
Course name/Established year/No. of students	Bachelor of Architecture Program in Industrial Design/1977/(n/a)				
Degree name	Bachelor of Architecture (Industrial Design)				
Course duration	5				
Over all credits	180				
General education	30	Core modules	144	Elective modules	6
Access from	http://www.reg.kmitl.ac.th/curriculum/curriculum.php?faculty_id=02&dept_id=03&curr_id=33&year=2552				
Date of access	17/03/14				

Modules:

No	Module Names	Credit	Type	Type				Envi	Soci	Ecn	Yr	Remark
			C/E	CC/G	L	P	S					
1	Human and Environment (H)	3	E	G	3	0	6	/			n/a	
2	Natural Resource Conservation (H)	3	E	G	3	0	6	/			n/a	
3	Thai Art (H)	3	E	G	3	0	6		/		n/a	
4	Environmental Study (S)	3	E	G	3	0	6	/			n/a	
5	Thai Product Deign	3	C	CC	2	2	5		/		4/2	
6	Sustainable Design	3	E	CC	2	2	5	/	/	/	n/a	
7	Life and Environment	2	E	G	2	0	0	/			n/a	

Remarks:

-

Appendix C: An example of completed TQF 3 retrieved from Mahidol University

Course Specification

Name of institution	Mahidol University
Campus/faculty/department	-

Section 1: General Information

1. Course code and course title	
Thai	มมศท ๑๐๓ ศิลปวิทยาการเพื่อการพัฒนามนุษย์
English	MUGE 103 Arts and Science for Human Development
2. Number of credit	2 (1-2-3) (lecture 1 hour – laboratory 2 hours/ self study 3 hours/ week)
3. Curriculum and type of subject	
3.1 Curriculum	offer in every curriculum in bachelor's level (except international curriculum)
3.2 Type of subject	Core course, General Education, Social Science and Humanities
4. Responsible faculty member	Full-time faculty members, Faculty of Social Science and Humanities, Mahidol University
5. Trimester / year of study	
5.1 Trimester	1 and 2 / First year
5.2 Number of students	_____ students
6. Pre-requisites	-
7. Co-requisites	มมศท ๑๐๑ การศึกษาทั่วไปเพื่อการพัฒนามนุษย์ MUGE 101 General Education for Human Development มมศท ๑๐๒ สังคมศึกษาเพื่อการพัฒนามนุษย์ MUGE 102 Social Studies for Human Development
8. Venue of study	Mahidol University, Salaya campus
9. Dare of latest revision	May 2009

Section 2: Goals and Objectives

1. Goals:
To let the students having knowledge in relation to humankind in the past, present, and future events/situation/problems in relation to the evolution of the arts and sciences in the Thai and global communities; concept of the sufficiency economy: students will be able apply knowledge to analyse of causes and consequences of events, synthesize of solutions to precautions against or improvements in those events/ situations to benefit individuals and their community.

2. Objectives of development/revision:
To revise course to be up-to-date and relevant to the current situation

Section 3: Course Management

1. Course descriptions
Humankind in the past, present and future; events / situations / problems in relation to the evolution of the arts and sciences in the Thai and global communications; concepts of the sufficiency economy; analysis of causes and consequences of events / situations / problem; synthesis of solutions to, precautions against, or improvements in those events / situations to benefit individuals and their community; and the application of knowledge to solve the problems of cause studies.

2. Credit hours / trimester

Lecture	Additional class	Laboratory / field trip/ internship	Self-study
15 hours (1 hour x 15 weeks)	-	30 hours (2 hours x 15 weeks)	45 hours (3 hours x 15 weeks)

3. Number of hours that the lecture provides individual counselling and guidance
1 hour / week

Section 4 Development of Students' Learning Outcome

1. **Expected outcome on students' skill and knowledge**
   Students will be able to apply the knowledge from lecturer and additional research with the ideas received from analysis and synthesis to set up solutions/ precautions to benefit individuals and their community;
2. **Teaching methods**
   Course organized using lecture and presentation methods. Teaching materials include documents and visual aids.
3. **Evaluation methods**

1. Morality and Ethics

1.1 Expected outcome on morality and ethics

(1) Perceive importance of morality, ethics, and integrity
(2) Have discipline, self and social responsibility
(3) Have a positive attitude in professional and express their morality and ethics
(4) Be responsible and participate in activity for development
(5) Can adjust to work in team both as leader or follower
(6) Respect and follow rules and regulations of institution and society
(7) Respect other people's right and are a good listener

1.2 Teaching methods

Learning Centred Education : Emphasis on knowledge development, important skills in career development and living, encourage students to use their full potentials

(1) Lecture
(2) Case studies with past experiences and current events
(3) Emphasis on morality and ethics
(4) Group discussion
(5) Group assignment

1.3 Evaluation methods

(1) Written examination
(2) Presentation
(3) Class attendance, class participation and behaviour in class
(4) On-time submission of reports and assignments and their quality

2. Knowledge development

2.1 Expected outcome on knowledge development

(1) Knowledge of theories and concepts in evolution of arts and sciences in the Thai and global communities

(2) Analysis of causes and consequences of events/ situations/ problems and solutions to current case studies

(3) Analyse impact of work and problems

(4) Keep up on academic progress and situations occurring in everyday life and global society

2.2 Teaching methods

Learning Centred Education : Emphasis on knowledge development, important skills in career development and living, encourage students to use their full potentials

(1) Lecture
(2) Case studies with past experiences and current events
(3) Emphasis on morality and ethics
(4) Group discussion
(5) Group assignment

2.3 Evaluation methods

(1) Written examination

(2) Presentation

(3) Class attendance, class participation and behaviour in class

(4) On-time submission of reports and assignments and their quality

3. Intellectual development

3.1 Expected outcome on intellectual development

(1) Have analytical thinking

(2) Can apply theoretical and practical knowledge to their real life activities

(3) Can apply knowledge and skill to solve problem and synthesize of solutions and precautions

3.2 Teaching methods

(1) Real experience teaching and encourage on skill development besides the professional skill
(2) Project assignment and presentation
(3) Analysis of case studies

3.3 Evaluation methods

(1) Presentation of knowledge synthesis
(2) Class attendance, class participation and behaviour in class
(3) On-time submission of reports and assignment and their quality

4. Interpersonal relationship and responsibility

4.1 Expected outcome on Interpersonal relationship and responsibility

(1) Express appropriate opinion

(2) Can adjust to work in team both as leader or follower

(3) Self-development both in academic and professional career and have responsibility for assignment (individual / group)

4.2 Teaching methods

(1) Group participation in case studies

(2) Assignment of group and individual reports

(3) Encourage real-life experience and current events in teaching

4.3 Evaluation methods

(1) Written examination

(2) Presentation

(3) Class attendance, class participation and behaviour in class

(4) On-time submission of reports and assignments and their quality

5. Mathematical analytical thinking, communication skills, and information technology skills

5.1 Expected outcome on mathematical analytical thinking, communication skills, and information technology skills

(1) Can use their effective communication skills (Listening, Speaking, Reading, and Writing) to communicate with others in group meeting, project workshop, and presentation

(2) Can use information technology for communication and presentation in appropriate ways

(3) Develop analytical skills from case studies

(4) Develop skills to search information from the internet

(5) Skills to use information technology for communication such as e-mail communication, group communication

5.2 Teaching methods

(1) Lecture and group discussion of case studies

(2) Practical in class

(3) Assignment for searching from website, e-learning and report with emphasis on mathematical numbers and statistics from reliable sources

5.3 Evaluation methods

(1) Group discussion

(2) Practical presentation in class

(3) Reports and presentation using information technology

(4) Participation in group discussion

Section 5: Teaching and Evaluation Plans

1. Teaching plan

Week	Topic	Hours	Teaching methods/ multimedia	Instructor
1	Development of the arts and sciences	**6**	Interactive lecture Group discussion	
2				
3				
4				
5				
6	Midterm exam			
7				
8				
9				
10				
11				
12	Final exam			

2. Evaluation plan

Expected outcomes	Methods / activities	Week	Percentage

Section 6: Teaching Materials and Resources

1. **Texts and main documents**
2. **Documents and important information**
3. **Documents and recommended information**

Section 7: Evaluation and Improvement of Course Management

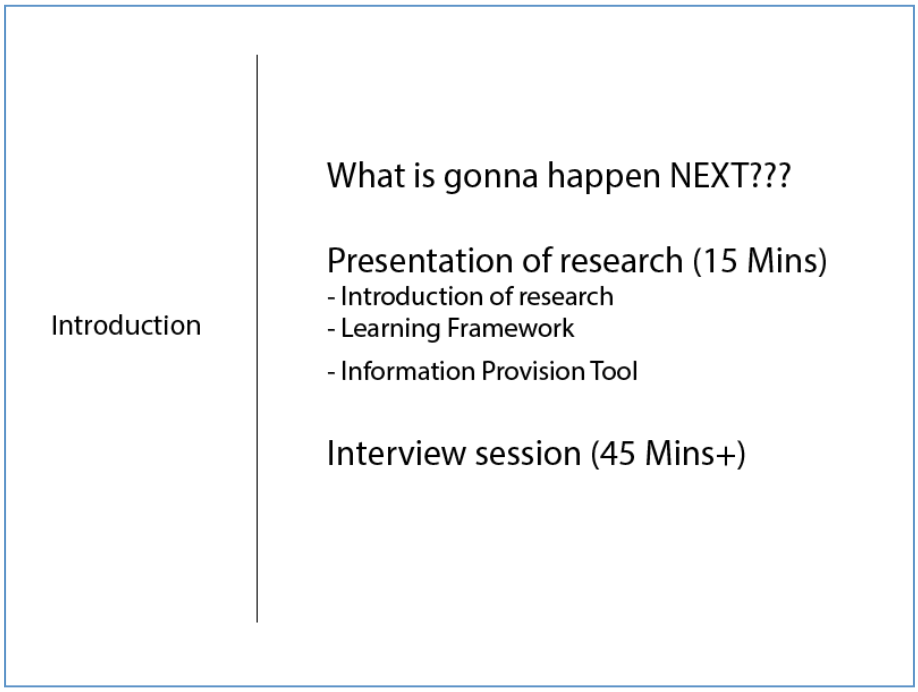
1. **Strategies for effective course evaluation by students**
    1.1 Evaluation of peers by students
    1.2 Student evaluation
        (1) Course content
        (2) Course management
        (3) Suggestions
        (4) Overall opinion
2. **Evaluation strategies in teaching methods**
    2.1 Student evaluation
    2.2 Presentation
3. **Improvement of teaching methods**

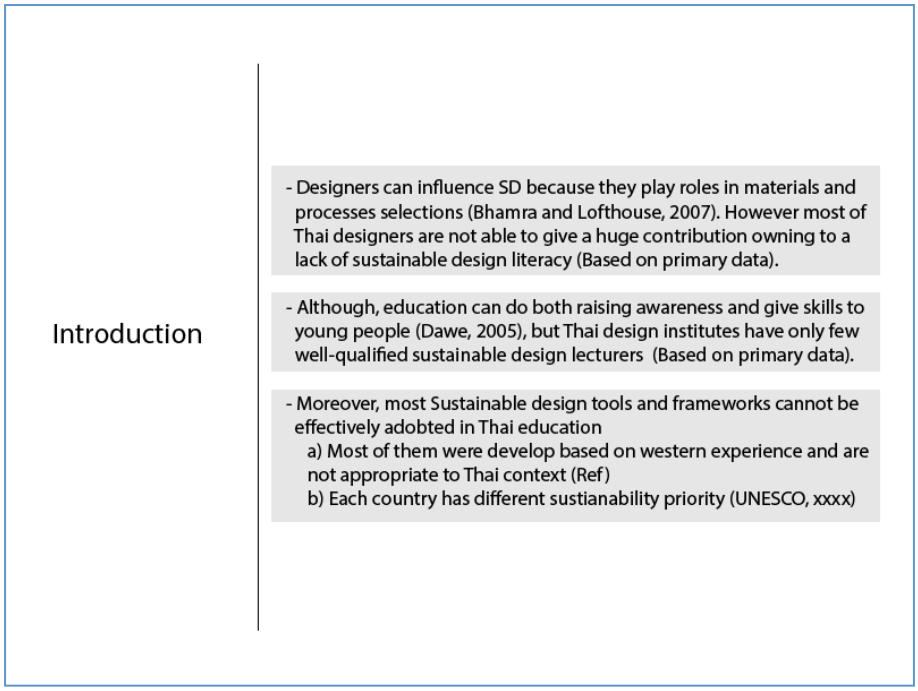
    Workshop on course improvement with the participation of all lecturers in this course
4. **Evaluation of students' learning outcome**

    Analysis of students' learning outcomes using scores from class attendance, group activity and presentation of project and poster presentation
5. **Review and improvement for better outcome**

    Meeting of lecturers to review the course before semester starts and before each period of teaching

Appendix D: PowerPoint presentation that was used in the empirical study





Introduction

These have inspired the researcher to contribute to the development of sustainable design literacy in industrial design education through...

- Developing the more appropriate framework for Learning and Teaching sustainable design for undergraduate Industrial/Product design courses in Thailand

- Developing the provisional tool that enables lecturers to effectively help students to acquire sustainable design competencies

This presentation is divided into two sections:
(1) Development of Learning and Teaching Framework
(2) Information Provisional tool

Learning and Teaching Framework

Sustainability education &learning approaches

What is Sustainable Development (SD)?

What is Education for Sustainable development (ESD)?

ESD was official introduced in Talloires Declaration since xxx (Ref) thus many research have been carried out. A list below show some existing learning approaches from selected publication:

- Head, Heart, Hands (Sipos, 2008)
- Focus on competencies
- System thinking (Porter, 2009)
- Service learning (Ref)
- Affective domain (Shepherd, 2007)
- Lecturers as a learners (Dawe, 2005)

***In this study, various approaches are combined and applied in order to develop the appropriate framework for Thai design students**

Learning and Teaching Framework

Sustainability Competencies

In order to develop a new learning framework or courses, educators are required to consider learning outcomes (what learners should be able to do after finish the course) (CSCT, 2003; Wiek, 2011)

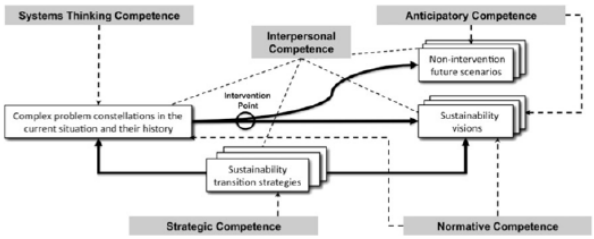
What are expected Sustainability competencies?

- Think systematically (Stering, 2001)
- Holistic thinking (Ref)
- Future thinking (Crofton, 2000)
- Inter-disciplinary (Wiek, 2011)
- Foresighted thinking (De-Hann, 2006)
- Critical thinking (Ref)
- so on.....

Learning and Teaching Framework

Sustainability Competencies

Specific key competencies for sustainability education (Wiek, 2011)



Learning and Teaching Framework

Learning domains
Bloom et al,1956

How to engage?
Sipos, 2008

Cognitive Domain: Head (learning through lecture, reading, and discussion with critical thinking)

Normative competence
System thinking competence
Anticipatory competence

Psychomotor Domain: Hands (learning by doing)

Strategic competence

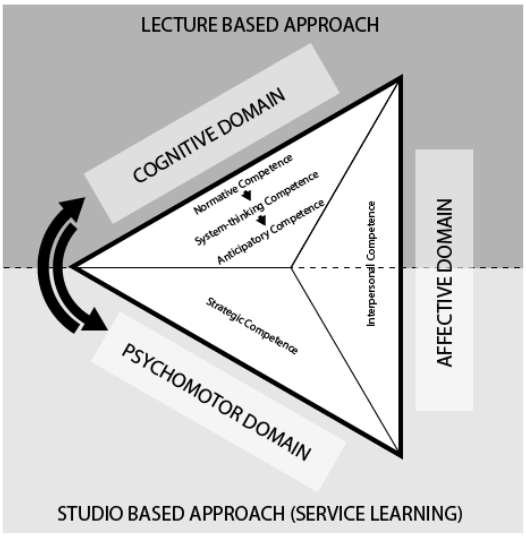
Affective Domain: Heart (experiencing, connection, and use of appropriate learning activities)

Interpersonal competence

*In order to achieve sustainability, learners are required to have appropriate knowledge & understanding, skill and motivation & correct values (Department of the Environment and Heritage, 2005).

Learning and Teaching Framework

Learning and Teaching Framework



Learning and Teaching Framework

Appendix E: Participant information sheet and consent form

LOUGHBOROUGH DESIGN SCHOOL

The Development of the Framework for the Learning and Teaching of Sustainable Design in Thai Higher Education

PARTICIPANT INFORMATION SHEET

Principal Investigators:
Dr Mark Evans, Senior Lecturer in Design, m.a.evans@lboro.ac.uk
Dr Debra Lilley, Lecturer in Design, d.lilley@lboro.ac.uk
Sarakard Pasupa, PhD student, s.pasupa@lboro.ac.uk

What is the purpose of the study?
The aim of this interview is to receive lecturers' opinion which will be use to refine the developed framework and tool.

Who is doing this research and why?
This study is a part of PhD research aiming to develop the framework for learning and teaching sustainable design.

Once I take part, can I change my mind?
Yes. After you have read this information and asked any questions you may have, I will ask you to complete an Informed Consent Form. You can withdraw at any time, for any reason and you will not be asked to explain your reasons for withdrawing.

How long will it take?
This interview would take approximately an hour.

What personal information will be required from me?
You will be asked about your background, organisation, and opinion.

Will my taking part in this study be kept confidential?
Yes

What will happen to the results of the study?
They will be used to inform PhD research. Extracts from this research will be presented within the PhD thesis which will be made publicly available via the University Library and Institutional Repository and may appear in published conference and journal papers.

Your identity will not be revealed in any written work unless authorised by you.

Personal details (name, address etc) will not be passed on to anyone.

What if I am not happy with how the research was conducted?
The University has a policy relating to Research Misconduct and Whistle Blowing which is available online at http://www.lboro.ac.uk/admin/committees/ethical/Whistleblowing(2).htm.

LOUGHBOROUGH DESIGN SCHOOL

The Development of the Framework for the Learning and Teaching of Sustainable Design in Thai Higher Education

INFORMED CONSENT FORM
(to be completed after Participant Information Sheet has been read)

The purpose and details of this study have been explained to me.

I have read and understood the information sheet and this consent form.

I have had an opportunity to ask questions about my participation.

I understand that I am under no obligation to take part in the study.

I understand that I have the right to withdraw from this study at any stage for any reason, and that I will not be required to explain my reasons for withdrawing.

I understand that all the information I provide will be treated in strict confidence and will be kept anonymous.

I agree to participate in this study.

Your name _____

Your signature _____

Signature of student _____

Date _____

Appendix F: Examples of the interview transcription and initial codes

Participant code: GOV2

Date: 11th April 2011

Place: National Metal and Materials Technology Center (MTEC) 114 Thailand Science Park, Paholyothin Rd. Klong 1, Klong Luang, Pathumthani 12120, Thailand

1	SP	Could you please tell me about your organisation?
5	GOV2	XCEP is a department in MTEC. We aim to help Thai manufacturing industry to develop eco-products (SSD/SO/AO). We have contributes to all processes such as engineering design and prototype (SSD/SO/A). However, we are quite weak in design (SSD/SO/A/C).
	SP	Could you please tell me about your background?
	GOV2	I studied industrial engineer (PB/E) and worked about manufacturing processes such as engineering design and prototype. I have taught product design in engineering department (PB/WE) .
10	SP	How did you come to involve in the initiatives?
	GOV2	The government found LCA lab and eco-product development lab to promote eco-design (SSD/SO/AO). I was invited to help in the product development lab.
	SP	How do you define Sustainable Design?
15	GOV2	We rely on the concept of triple bottom line. In other words, people should not compromise to the resources of the next generation (PB/USD).
	SP	What is the difference between Sustainable Design and Eco-design?
20	GOV2	They are quite similar but eco-design considers only two factors: economic and ecology. We do not give much focus on social aspect (SSD/SO/A).
	SP	Do you use any Sustainable Design tools?
25	GOV2	We have used eco-assessment tools such as Sima Pro, J-mind, and Garbi. They enable manufacturers to evaluate environmental impacts (e.g. carbon footprints).
	SP	What do you think about the status of Sustainable Design in Thailand now?
30 35	GOV2	Thai residents have awareness and willing to be more environmentally friendly. However, they have no understanding on eco-design (SSD/T). Although we have done some activities, they are not enough to create a great impact because we are not in the same track (SDI/D/C). Government agencies have launched many schemes that are related to the concept but they do not link together. We should have national agenda that lead everyone to the same direction (SDI/D/C).
	SP	Could you please tell me about eco-design award?
	GOV2	In the first year, we focused on all targets: secondary students,

40		undergraduate students, designers, and SMEs. This is because it aimed to educate people. This year, we give more focus on professional designers and SEMs (SDI/P).
	SP	Why do you think participants want to gain understanding of sustainable design?
45	GOV2	It is because of trend and everybody would like to support eco-design (SDI/P/I). We would like to provide the right information. Most people focus on global warming due to trend but they don't know how to be sustainable (SDI/AO).
	SP	What medias are used in the knowledge transfer of eco-design?
50	GOV2	Candidates were required to attend Learn@nline. We utilised design case studies from previous contests to teach our candidates (SDI/TM).
	SP	Did you group candidates before giving a lecture?
	GOV2	No, all together
55	SP	Do you introduce any sustainable materials in the initiative?
	GOV2	We invited TCDC and Materials Connextion to give lectures in the initiatives (SDI/TM). Nevertheless, they just provided some ideas but did not much in details.
	SP	Do you introduce any sustainable design tools in the lecture?
60	GOV2	Yes, we let them know about life cycle thinking. Then introduce some tools (SDI/Info). The specific problem of Thailand is people do not consider all life cycle. They focus on their issues only. This may lead others to get into trouble (SSD/SO/A/C).
	SP	Are your aware of sustainable design tools for designers?
65	GOV2	We have developed an assessment tool for designer called "SEPPE". It is similar to LCA but easier. We also use sustainable a plug-in of solid work (SSD/SDR).
70	SP	Do you collect any feedback?
	GOV2	We have done some but they just checked the satisfaction of participants. This contest has inspired some participants (SEMs) to implement eco-design into their manufacturing processes (SSD/SDC/IISD).
	SP	How many participant in the third year
75	GOV2	We got over 300 groups (SDI/P).
	SP	Any of your initiatives linked to Thai design education (bachelor degree)?
80	GOV2	Last year, we gave scholarships to students who conduct thesis projects that are related to sustainable design (SSD/SO/A). We have provided lecture in some institutions. Most participants are graduate students and lecturers who interest have conducted research in this

		area. We have cooperated with Thai universities (e.g. Thamasat University, KMITL, Chiang Mai Unversity, and Naresuan University) to establish eco-design centre.
85	SP	What departments have you worked with?
	GOV2	Design and engineering
	SP	I have heard that students were require to attend a camp. How long did it take?
90	GOV2	Selected candidates (about 80 students) were required to attend a 3 day camp.
	SP	How many candidates were involved in the contest?
	GOV2	We got around 200 groups in the first year. Then 300 and 280 in the second and third year respectively.
95	SP	Does the organisation have any future goals for the sustainable design initiatives?
100	GOV2	Previously, we have focused on production only. So we plan to give more focus on consumption. We aim to educate consumers to have more understanding and develop green labels. The labels will give more convenience to consumer for making decision to buy eco-product. We will offer lectures to teach brand owner to create the labels.
	SP	Will you offer more resources of sustainable design?
	GOV2	We just launched a new website for eco-product.
	SP	Have any specific tools for design students?
105	GOV2	Not yet. However, students have interested in the web-based information. Some of them have asked for the website to do their reports.
	SP	How about TGDN?
110	GOV2	It is not active because we do not have time to update. However, it will be better because now we have a volunteer (private organisation) to look after the website.
	SP	Do you have any future goals for the contest>
	GOV2	We will give more focus on the industry and change the format. We plan to pick the winner from existing products.
115	SP	How about students?
	GOV2	We may not allow them to attend the next year contest due to the lack of budget.

Appendix G: Interview questions for participants

A set of questions for participants in lecturer group

Questions to investigate into the Thai context (findings presented in Chapter 4)

Participants' background and teaching module(s)
- Could you please tell me about your background (education and employment)?
- What do you teach in the course?
- How do you acquire the contents that are used in your class?

Sustainable Design knowledge
- How do you define Sustainable Design?
- What is the difference between Sustainable Design and Eco-design?
- Have you heard about Triple Bottom Line?
- Do you use any Sustainable Design tools?
    - Do you aware of any others?

Attitude
- Does the university have a sustainable design module (stand alone)?
    - If yes, is it enough? Why?
- Have you taught or are thinking about teaching concept-related sustainable design in your classes?
    - If yes, how many classes (hours) are dedicated to teaching sustainable design? Why?
- Do you think teaching sustainable design is important & want to integrate it in your course?
- What are barriers to learning & teaching sustainable design?

Questions for the evaluation of the framework and *SustainAble* web-tool (findings presented in Chapter 6)

- What do you think about the framework and web-tool?
- Could you see yourself using the framework or web-tool to improve your teaching?
- What do you like or dislike in this framework and web-tool?
- Do you have any comments that may benefit the framework and tool development?
- What should be added or deleted?

A set of questions for participants in government agency group

Participants' background

- Could you please tell me about your organisation
    - What is the aim of your organisation?
    - Organisation structure
- What does your organisation attempt to achieve in sustainable design initiatives?
- How the initiatives relate to the aim of your organisation?

- Could you please tell me about your background?
    - Education
    - Employment
- How did you come to involve in the initiatives?

Sustainable Design knowledge

- How do you define Sustainable Design?
- What is the difference between Sustainable Design and Eco-design?
- Have you heard about Triple Bottom Line?
- Do you use any Sustainable Design tools?
    - Do you aware of any others?
- What do you think about the status of Sustainable Design in Thailand now?

Sustainable Design initiatives

- What sustainable design initiatives has your organisation launched?
- Who participated in these initiatives? (e.g. students, managers, manufactures)
- Why do you think participants want to gain understanding of sustainable design?
- What medias are used in the workshop?
    - Why were they employed?
- What type of information is provided in the initiatives?
    - Do you provide any example in the initiatives? If yes, what are they? (e.g. design case studies, example of materials or products)
    - Do you introduce any sustainable design tools in the lecture (e.g. LCA, LCI)? If yes, what are they?
    - Are your aware of sustainable design tools for designers? If yes, what are they?
    - Do you collect any feedback? If yes, can you show the feedback that you collected?

Any of your initiatives linked to Thai design education (bachelor degree)?
- If yes, what are their aim and objectives?
- Which media are used in the initiatives?
- Which institutions have you collaborated with?

Future plan
- Does the organisation have any future goals for the sustainable design initiatives?
    - Will you offer more sustainable design initiatives in the future?
    - Will you offer more resources of sustainable design?

Appendix H: Examples of Design cases-studies that will be included in the web-tool

Design case studies of Thai companies presented in this appendix will be include in the information section of the *SustainAble* web-tool.

Yothaka is a furniture company in Thailand who applies Thai traditional skill and Thai materials in its products, an example is shown in the figure below:

Water hyacinth furniture (Yothaka, 2010)

The company was established in 1989 by a group of product designers who received funding from Canada to develop water hyacinth as a base material for the furniture industry. They achieved "the Best environmentally friendly design" from design organisation in Canada (Merten, 2007). The company has two hundred employees and produces a revenue of 1.5 million. Eighty percent of their income is derived from export; its products are available in the EU and the US. The design direction of the company is comprised of two aspects,

- To create revenue, Yothaka focus on commercial products, which enables them to reach their profit target and allow consumers to access their products at a reasonable price.
- To create a brand image, they design products that have a unique design to be brand representatives.

The owner of the company also reveals that the team try to use regional materials and handicraft skills because they enable the company to compete with western products and create more income for rural people (Yothaka, 2010).

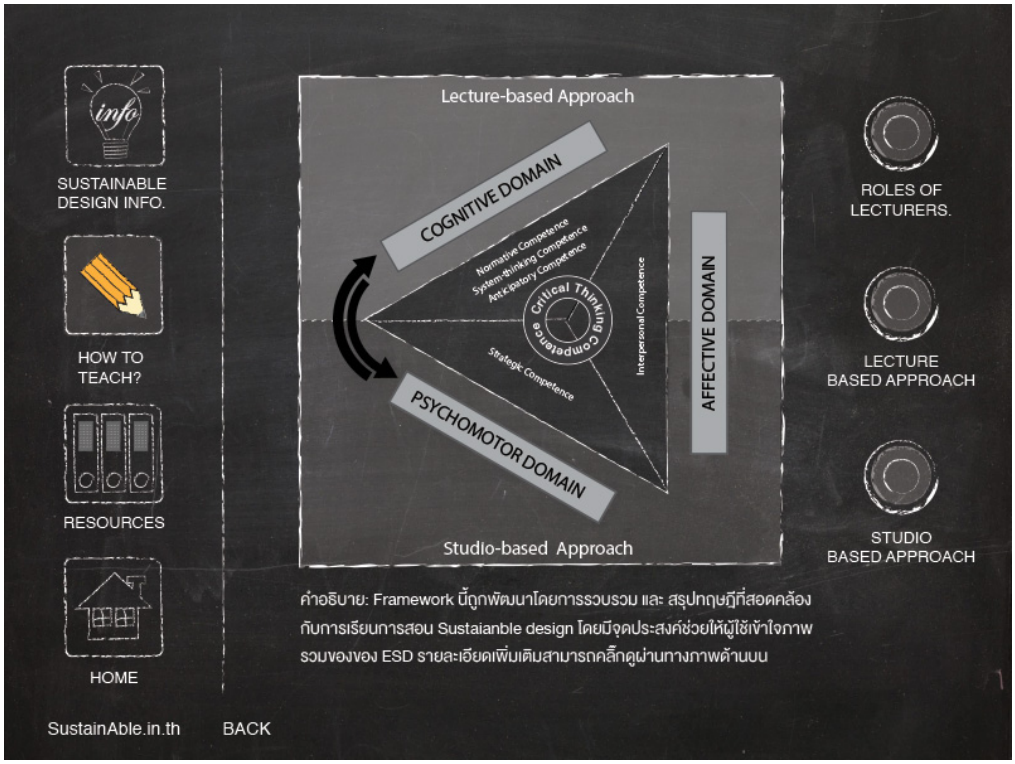
Korakot International Limited Partnership was founded in December 2006. Aromdee has played two roles, an owner and a designer. The designer applied 'tie and knot' from the Thai traditional kite into his design (decorative items). His design has been awarded a international prize and exhibited in many international fairs such as Tokyo Lift Style and Maison & Object in Paris (Black, 2008). His company also offer career opportunities to the rural residents; most of his production staffs were local (Korakot, 2008).

Korakot Lamp (Korakot, 2008)

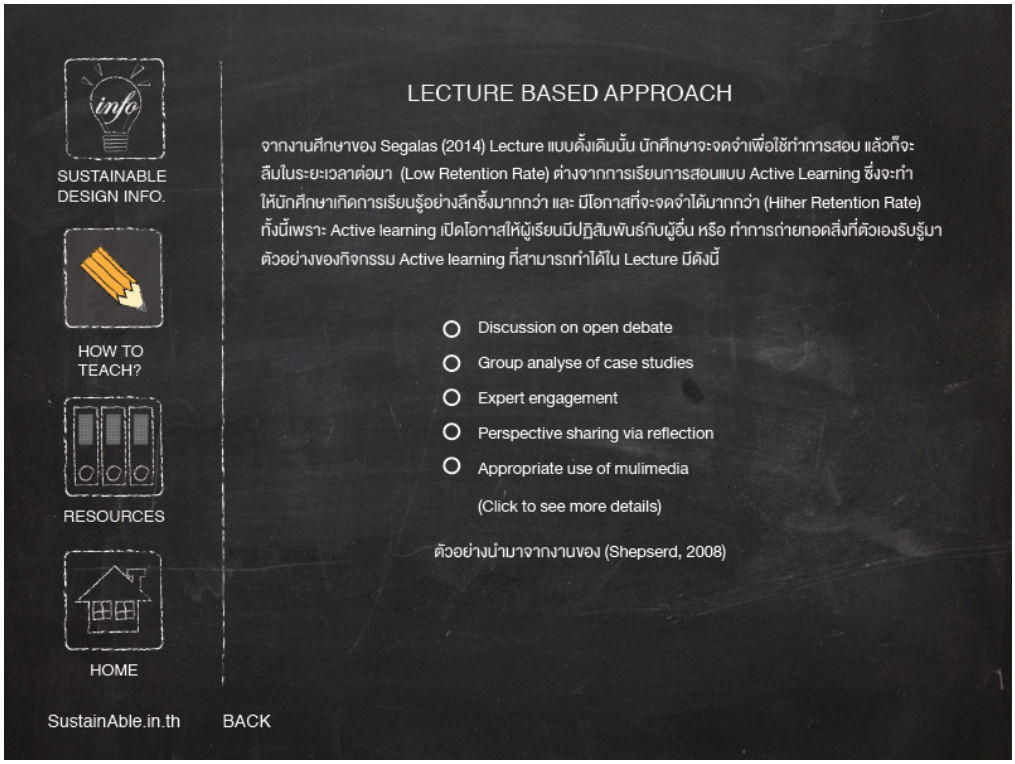
Osisu is a furniture company, which has built a reputation for the use of reclaimed materials. Intrachooto, the owner (an architect and a product designer), he has a strong background in eco-design. The company was established with the intention to utilise waste materials from construction sites and/or product manufacturing (Osisu, n.d.). Examples of its products are displayed below:

Left teaks (left) and exhaust pipes from the automotive industry (right), which have been made into benches and stools (Osisu, 2008)

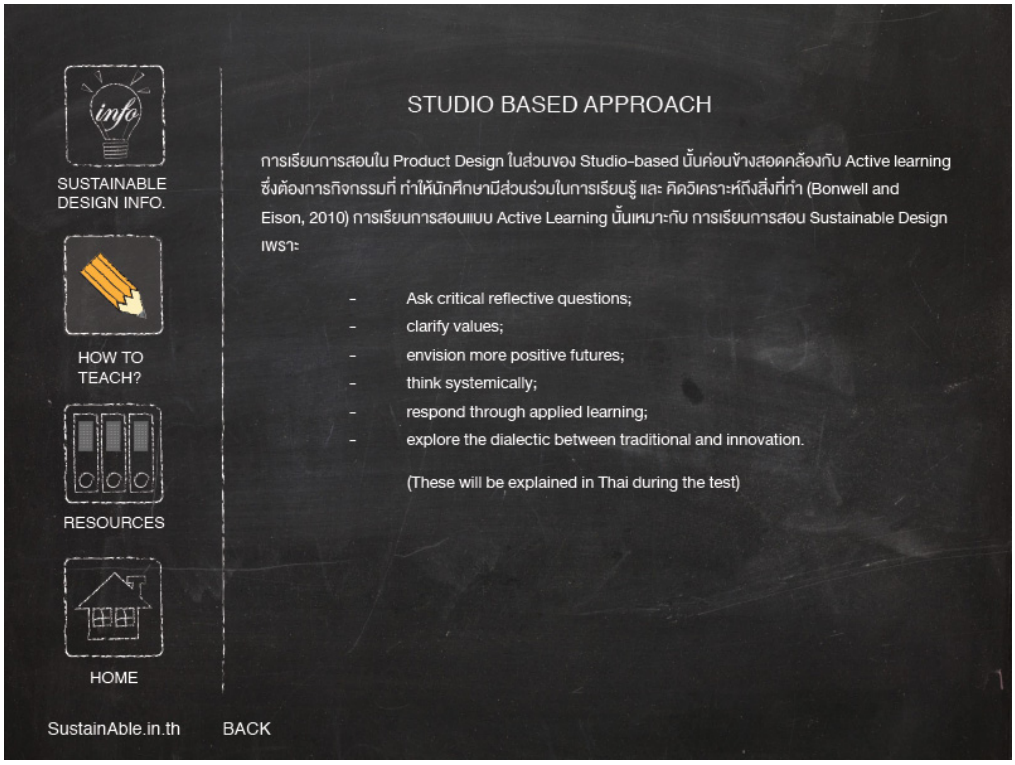
Screenshot 1: Homepage



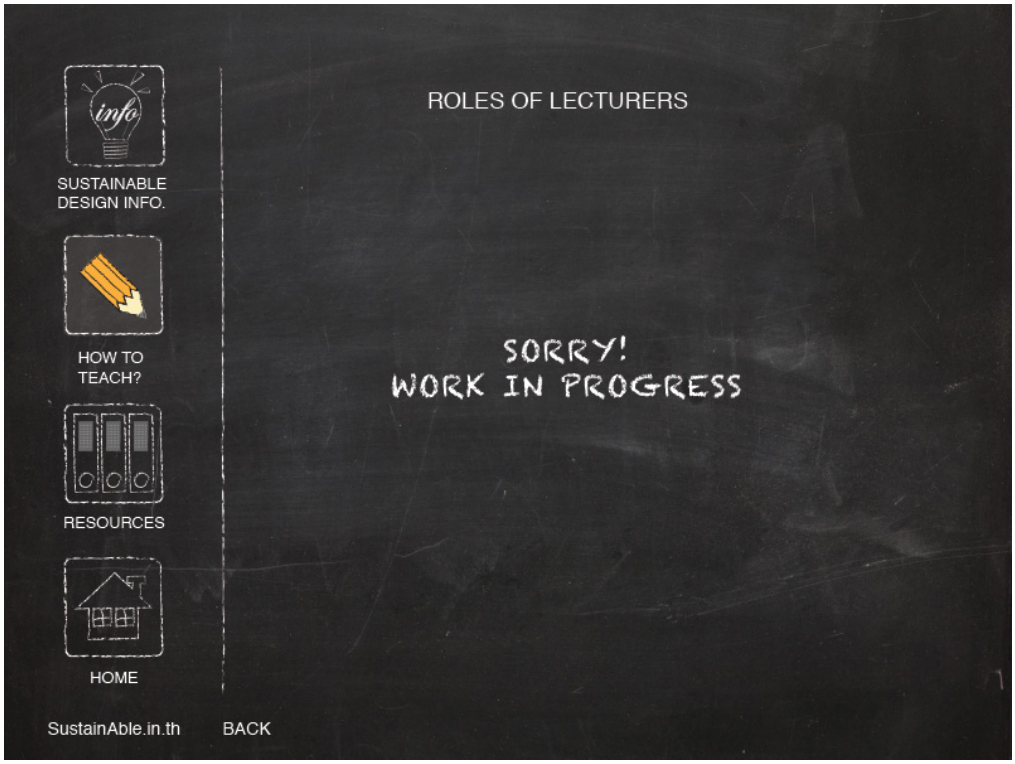
Screenshot 2: How to Teach Main Webpage



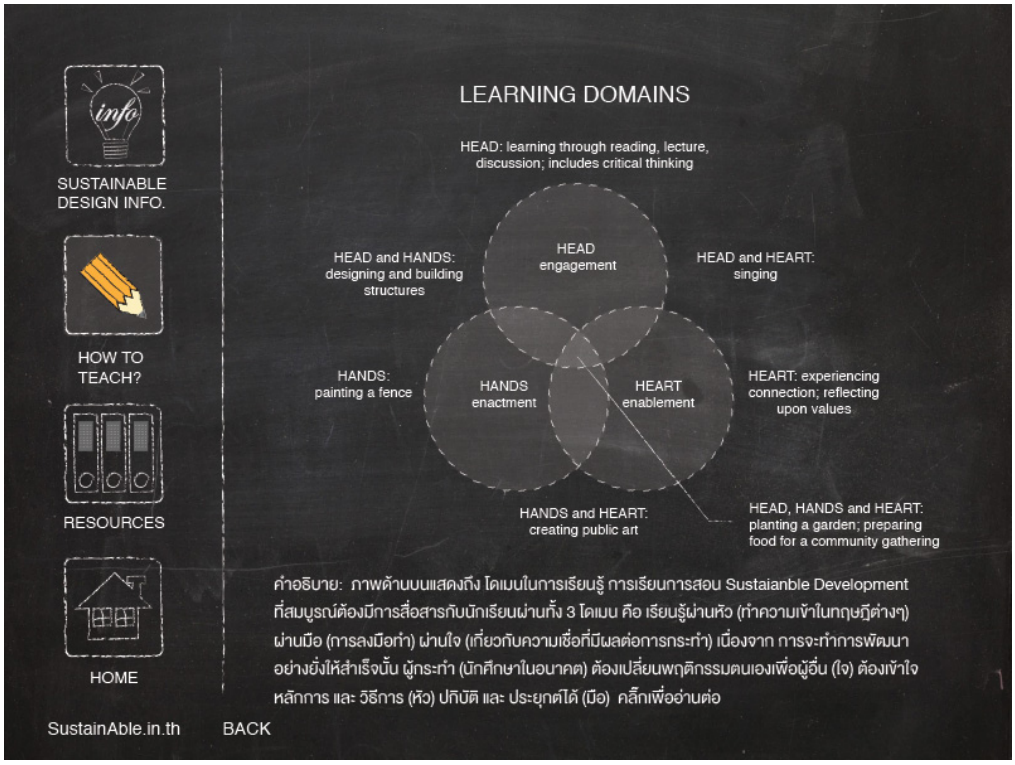
Screenshot 3: Lecture-based Approach



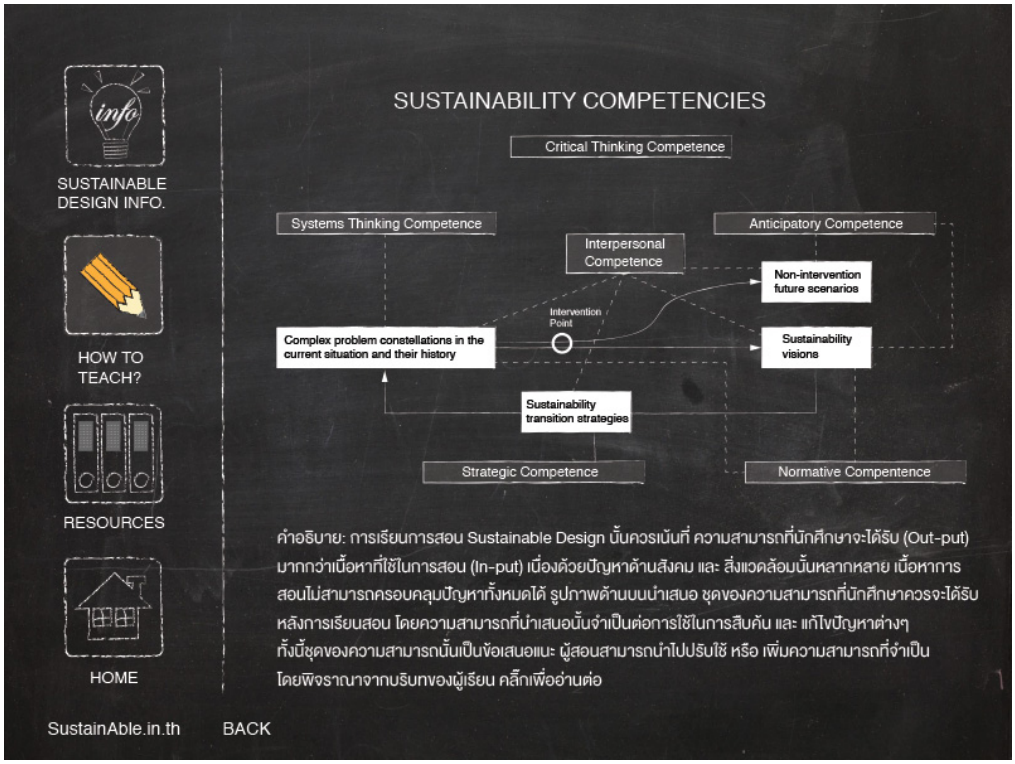
Screenshot 4: Studio-based Approach



Screenshot 5: Role of Lecturer

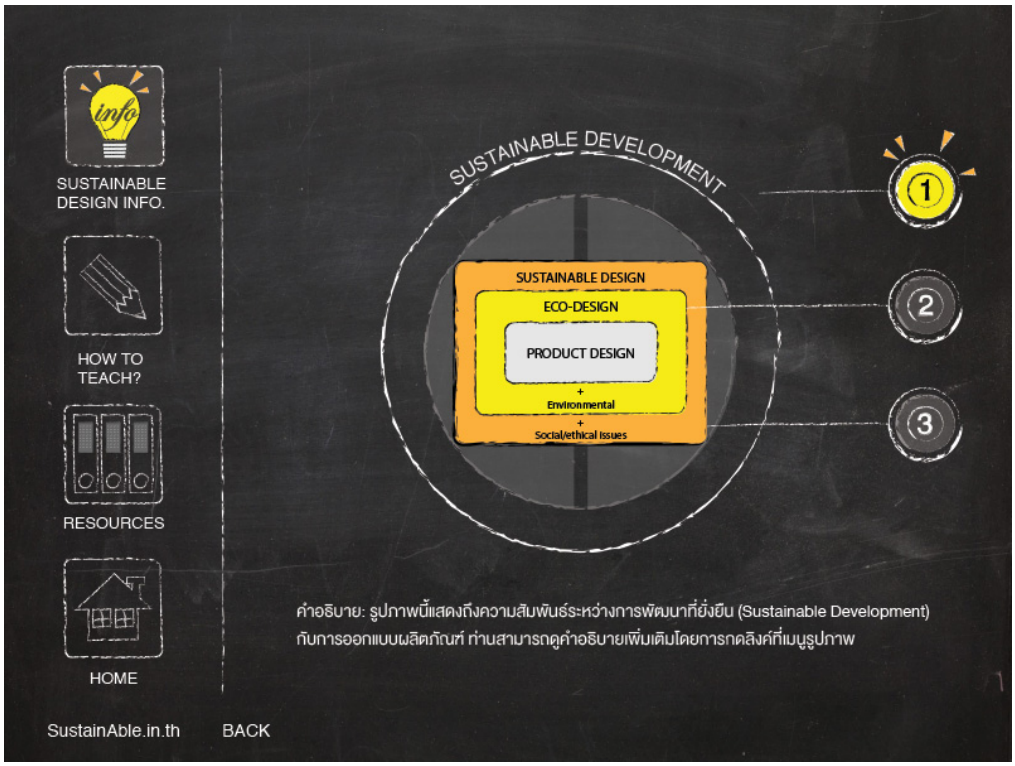


Screenshot 6: Three learning Domains

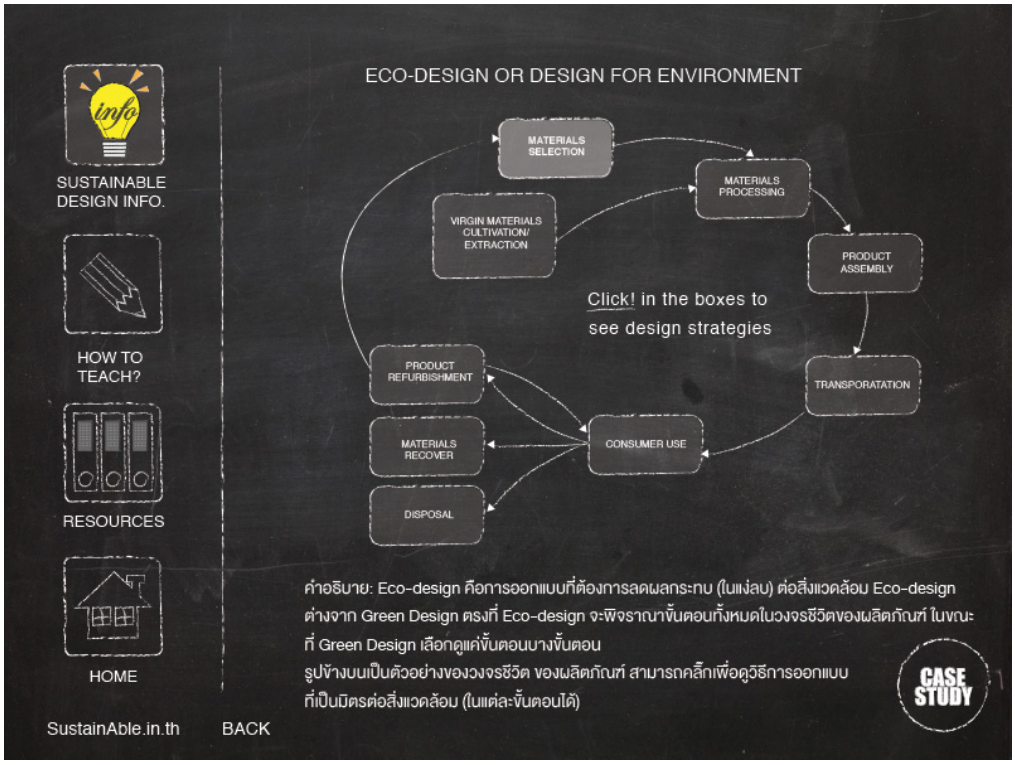


Screenshot 7: Set of Required Competencies

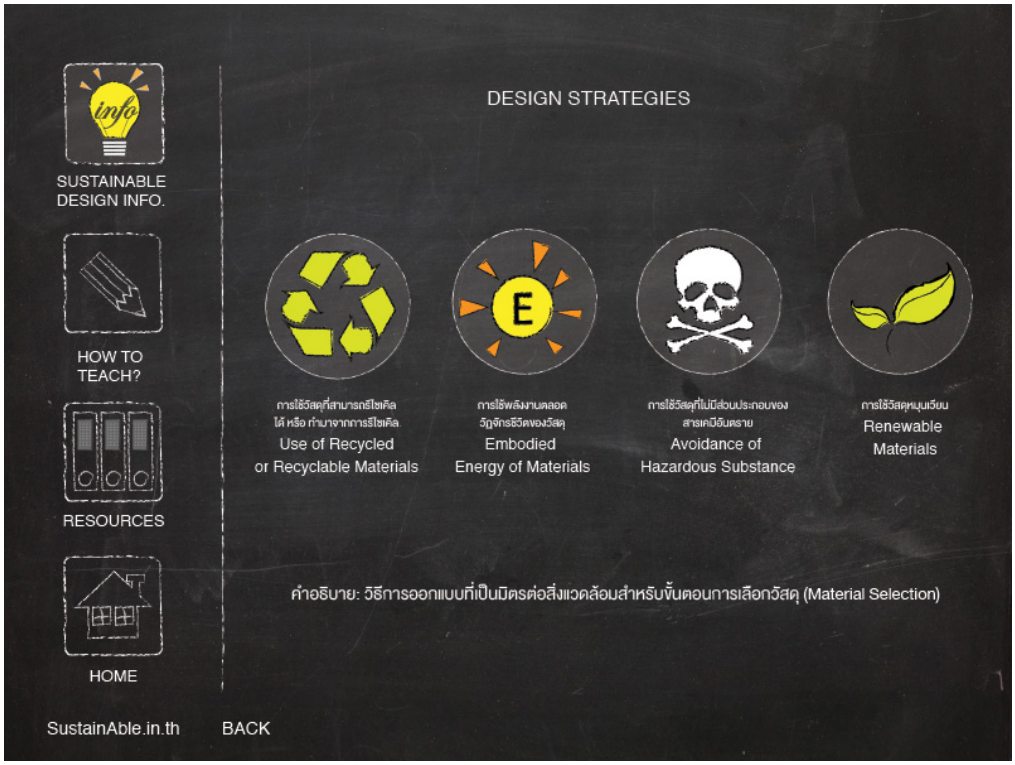
Screenshot 8: Set of Required Competencies (Details)



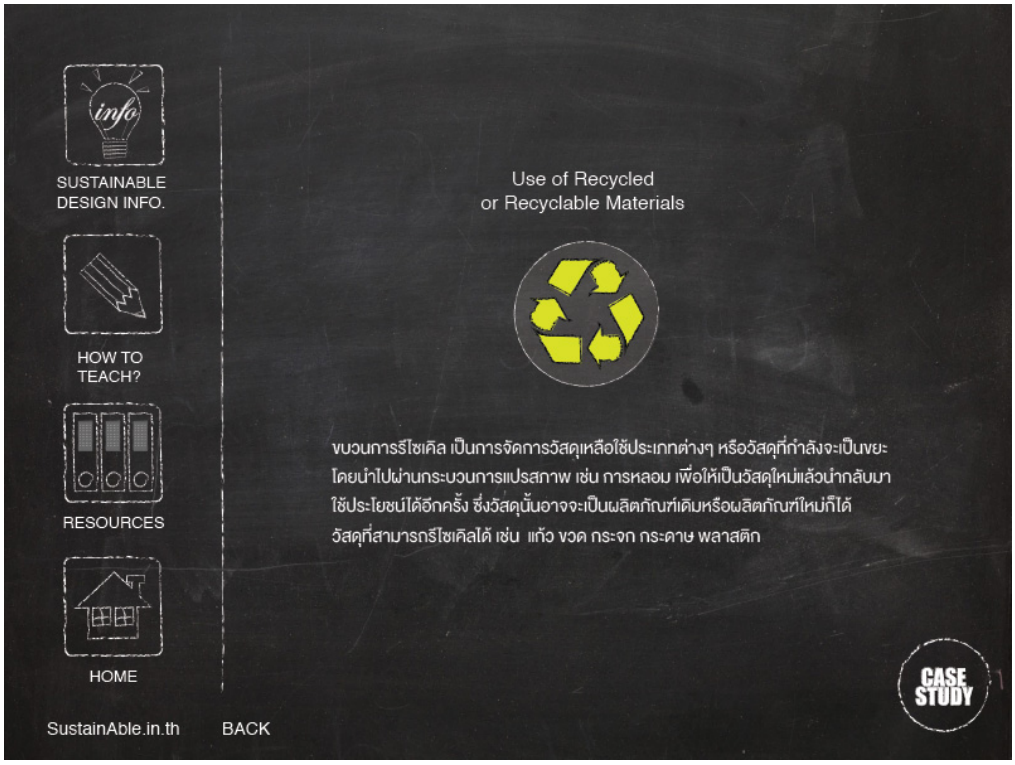
Screenshot 9: Sustainable Info Main Webpage



Screenshot 10: Eco-design Principle



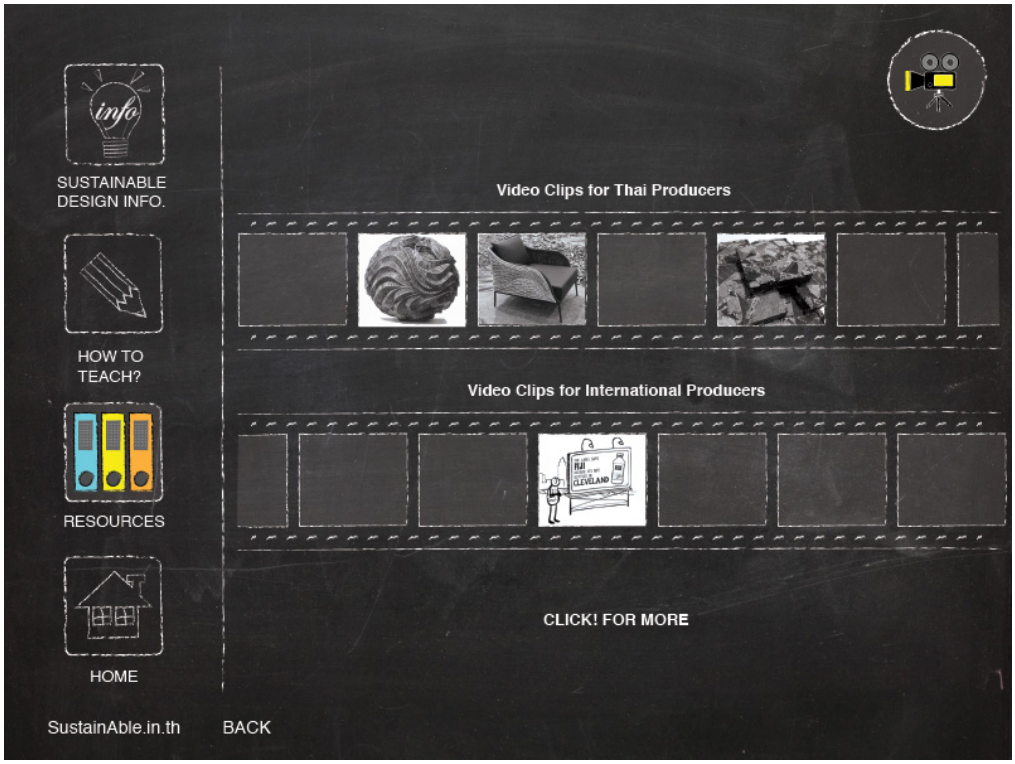
Screenshot 11: Design Strategies for Material Selection



Screenshot 12: Individual Webpage for Each Strategy

Screenshot 13: Design Case-study for The Strategy (Use of Recycle Materials)

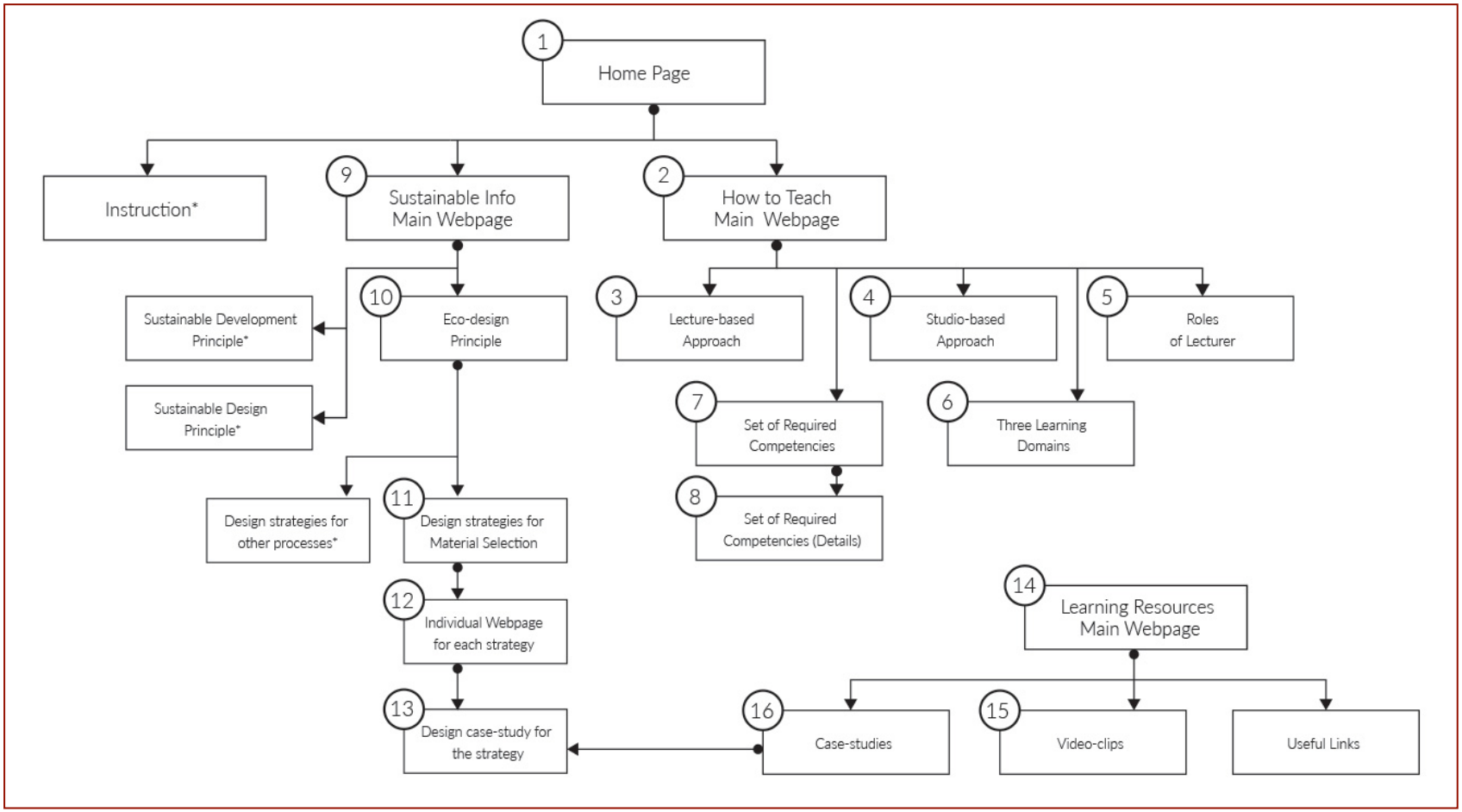
Screenshot 14: Learning Resources Main Webpage



Screenshot 15: Video Clips

Screenshot 16: Design Case-studies

Appendix I: Screenshots of *SustainAble* web-tool (prototype)



Sitemap for the Web Tool Prototype