ENGINEERING EDUCATION FOR SUSTAINABLE DEVELOPMENT (EESD) FOR UNDERGRADUATE ENGINEERING PROGRAMMES IN MALAYSIA: A STAKEHOLDER DEFINED FRAMEWORK

SUBARNA SIVAPALAN, BA, MA

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DECLARATION

I declare that this thesis is a product of my own work, which has not, whether in the same or a different form, been presented to this or any other university in support of an application for any degree other than that of which I am now a candidate.

SIGNED: ....

SUBARNA SIVAPALAN

2015

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DEDICATION

I would like to dedicate this thesis to my 7 year old daughter, Yuvena, who has been an amazing, patient and understanding daughter, throughout the years I had been working on my PhD.

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ABSTRACT

The Institution of Engineers Malaysia (IEM) and the Board of Engineers Malaysia (BEM) stress the need for Malaysian engineering graduates to be able to integrate sustainable development knowledge, skills and values in their professional practice. The 2012 Engineering Accreditation Council (EAC) manual outlines 12 outcomes that students of Malaysian institutions of higher learning offering engineering programmes are expected to develop upon completion of their studies. Of the 12 outcomes, three are explicitly linked to sustainable development. While institutions of higher learning are required to develop the prescribed skill set using outcome based approaches to learning, integration measures are not specifically stipulated. 30 hypothetical competences were developed as a means of addressing the issue of integrating sustainable development outcomes within the undergraduate engineering programme curriculum. Using a private higher learning institution offering engineering programmes as a case study, this study set out to explore the views of the institution's stakeholders, i.e. the final year undergraduate engineering students, academicians, university management and engineers, as well as education for sustainable development experts and ESD practitioners on (a) the extent to which sustainable development and education for sustainable development is incorporated within the engineering curriculum of the higher learning institution (b) the inclusion of sustainable development programme and module learning outcomes within the undergraduate engineering curriculum and how it can be included within the curriculum, and (c) the additional components needed for the EESD framework for undergraduate engineering education in Malaysia. Respondents' perspectives were sought through a triangulation mixed methods approach, through surveys, interviews and analysis of documents. Findings of the study were then used to develop the proposed (a) guidelines to incorporate sustainable development competences holistically within undergraduate engineering programme outcomes and common module learning outcomes, and the (b) Whole Institution EESD Framework.

Keywords: Engineering Education for Sustainable Development (EESD), Education for Sustainable Development (ESD), Sustainability and Higher Education, Transformative Learning, Whole Institution Approach, Sustainable Development Competences, Mixed Methods Research, EESD framework, EESD guidelines

CHAPTER 1

INTRODUCTION

1.0 Introduction

The term sustainable development gained international attention and recognition in 1987, after the World Commission on Environment and Development's Brundtland Report report, *Our Common Future*. Sustainable development had initially been termed 'environment and development', development without destruction' and 'environmentally sound development' (Mebratu, 1998: p.501). Despite ambiguities in the manner in which the term had been defined, the description 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (World Commission on Environment and Development, 1987) has been key to developing a global understanding of sustainable development. This definition has since become the most widely received and used term in literature and research focused on sustainable development. It was also through this particular report that the term sustainable development became a global concern.

It is widely known that the years 1987 and 1992 are significant milestones in the sustainable development timeline. Historically though, Mebratu (1998) notes that that the origins of sustainability can be traced prior to these milestones. Mebratu asserts that the sustainable development historical timeline can be divided into three periods, namely the Pre-Stockholm period (-1972), the period from Stockholm to the World Commission on Environment and Development (1972-1987) and the post-World Commission on Environment and Development period (1987-1997). The key events that took place within these three periods are briefly discussed in the paragraphs that follow.

In 1972, the United Nations Conference on Human Environment made clear indications of the need to manage the environment using environmental assessment as an instrument. As the boundaries of defining sustainable development had not been specific, Azar, Holmberg and Lindgren (1996) explain that opportunities for placing an indicating value for sustainability were not possible. In 1992, 178 countries pledged support to address problems surrounding environmental protection and socio-economic development. This pledge of support resulted in the adoption of Agenda 21.

The United Nations Conference on Environment and Development, i.e. the Earth Summit was held in Rio de Janeiro, Brazil. A significant outcome of the summit was strategies for Agenda 21, an action plan or agenda for the move towards sustainability in the 21st century. Through Agenda 21, sustainability is seen as a steering standard for 21st century development around the world. Agenda 21 consists of 40 chapters which are divided into four sections which include social, economic, conservation and resource management (United Nations, 2009). Also outlined is the reinforcement of major group, where it is the responsibility of engineers, architects, industrial designers, urban planners and policy makers to contribute more effectively towards environmental and developmental concerns (United Nations, 2009).

Well informed global and local sustainability agendas are also essential for Agenda 21 to be carried out effectively. The formation of policies, governmental and non-governmental strategies informing sustainability exemplify some of the measures that have been taken by nations around the world to ensure sustainable development is pursued intently and systemically within the local and global context.

Although sustainability differs according to context and culture, strategies initiated are mostly similar. In the United Kingdom for instance, a sustainable development strategy now commonly known as Securing the Future was initiated by the government in the year 1999. The aim of this strategy was to aid in bringing about an enhanced quality of life through sustainable development (Blair, 2005). At the non-governmental level, organizations such as Forum for the Future and StudentForce further take the government’s sustainable development visions to greater heights.

Sustainable development is also viewed seriously in the Netherlands. The year 2003 for example saw the Dutch government establishing the Sustainable Action programme. In the year 2008, governmental policies were revised through the Kabinetsbrede Aanpak Duurzame Ontwikkeling programme (the cabinet wide approach). Through the Kabinetsbrede Aanpak Duurzame Ontwikkeling programme, three approaches were identified as vital to further the sustainable development agenda, namely the establishment and accomplishment of policy outcomes, the incorporation of sustainability in the government's daily operations and establishing dialogue with the society (European Sustainable Development Network, 2011).

Malaysia, at the Copenhagen 15th United Nations Framework Convention on Climate Change (COP15) meet, pledged to reduce the nation's emission intensity by up to 40% by the year 2020. In July 2009, the National Green Technology Policy National Policy on Climate Change were developed in response to this pledge. Malaysia's National Green Technology Policy, according to Datuk Loo Took Gee, the Secretary-General, Energy, Green Technology and Water Ministry 'serves as the basis for all Malaysians to enjoy an improved quality of life, by ensuring that the objectives of our national development policies will continue to be balanced with environmental considerations' (The Star, November 27, 2010: p. 28). Accentuating the need for sustainability further is the incorporation of green technology elements in projects under the 10th Malaysia Plan. According to Malaysia's Work Minister, Datuk Shaziman Abu Mansor, as reported in The Star, the Ministry has set a target of 40% for green technology derived projects and is open to new technology in the engineering and construction sectors to further develop greening efforts (May 20, 2011). The importance of sustainable development for Malaysia was further emphasized when the Prime Minister affirmed that the nation's human capital plays an eminent role in championing the need for a sustainability driven nation. During his address at the Commonwealth Business Council in December 2009, Prime Minister YAB Dato' Sri Haji Mohd Najib bin Tun Haji Abdul Razak explained the importance for Malaysia to nurture sustainability competent human capital if the nation was to resolve its sustainability challenges.

In discussing the need to develop sustainability competent human capital to remedy the nation's sustainability challenges, the pivotal role played by the country's national education system needs to be reassessed. The Malaysian National Education Policy, of which the seven National Higher Education

Strategic Plan (NHESP) thrusts are also based on, emphasises the need to develop individuals who have the capability to contribute to the advancement of the society and nation.

> Education in Malaysia is an ongoing process towards further effort in developing the potential of individuals in a holistic and integrated manner; so as to produce individuals who are intellectually, spiritually, emotionally and physically balanced and harmonious, based on a firm belief in and devotion to God. Such an effort is designed to produce Malaysian citizens who are knowledgeable and competent, who possess high moral standards, and who are responsible and capable of achieving a high level of personal wellbeing as well as being able to contribute to the betterment of the society and the nation at large.

(Malaysia Education Blueprint 2013-2025: Ministry of Education: 2013)

As such, given that sustainability has been, and will continue to be important national and global agendas for the country within political, economic, social, scientific and educational ambits, it is thus important for Malaysia's National Education Policy to be aligned with the country's developmental agenda. Additionally, Malaysia's education sector must also consider the vital role of ESD within its national education system, given the fact that the majority of the country's human capital are products of the country's primary, secondary and tertiary education system. Likewise, within the context of higher education, specifically engineering education, the need to instil EESD awareness and competences is also crucial, as 'the need to educate the engineer of the 21st century differently – or more precisely, more strategically – is essential to the endurance of the profession' (Galloway, 2008: p. 5).

There is therefore an urgent need for Malaysian universities to advance ESD & EESD amongst its engineering students and staff, so they would be better prepared to meet and embrace the sustainable development challenges the country will face, as it transits from a developing to developed nation by the year 2020. Given the above scenario, this study therefore unravels ways in which higher education in Malaysia, namely engineering education can play its role in developing environmentally considerate future engineers who have the ability to understand, appreciate and practise sustainable engineering to support the nation's sustainable development goals for 2020 and beyond. Chapter 1 thus sets the focus of the study, by establishing the need to re-look Malaysian undergraduate engineering programmes through a holistic lens which focuses on the whole institution, i.e. through policy, practice, leadership and the process involved in the practise of teaching and learning. The findings of this research contribute towards the improvement of pedagogy, (i.e. ways of teaching) and curriculum (i.e. ways of organizing teaching content) and institutional practices within the field of engineering education for sustainable development. As an academician and researcher, my contribution towards the sustainable development agenda is within the boundaries of education and scientific research. I strongly believe that both entities play significant roles in advancing a sustainable development agenda that is unbiased. It is therefore rather ironic that much of the scientific research carried out at present is largely focused on the technological aspects of sustainable development. Even though educational, social and human dimensions of sustainable development research do exist and are fast developing, these facets are usually seen to play a secondary role to research within the technological genre. Such research advancements are rather incongruous, given the fact that development and transformations envisioned from technological lenses have profound educational, social, economic, political and cultural impact, and provide a multifaceted impact on human development.

1.1 Background of the study

This section further develops the notion of the need to instil sustainable development awareness and competences amongst university engineering graduates. I begin the discussion of this section by establishing the need for professional and graduate engineers to be sustainable development competent. Instances of sustainable engineering initiatives undertaken by engineering organisations around the world and Malaysia are provided as evidence of the growing global demand for a sustainability competent engineering workforce. The section then proceeds with a discussion of the state of sustainable development within the Malaysian engineering workforce, and the need to nurture Malaysian graduate engineers who are more compassionate about sustainable development and sustainable engineering. The section ends with a reinforcement of the need to integrate ESD philosophies within undergraduate engineering programmes offered by Malaysian universities.

1.1.1 Sustainable development and the engineering profession

Historically, the engineering profession has been witness to varying environmental, social and economic demands (Carew and Mitchell, 2001). The principle fundamentals of the engineering profession had initially been a possession of 'a broad spectrum of artistic knowledge, craftsmanship and management skills' (Kastenhofer, 2010: pp.44). In more recent times however, the profession has come to be a more specialized and technically focused vocation. The dawn of the industrial engineering era is said to be the root of this shift of perspective of the profession, and also signalled the beginning of engineers having to conform to industrial legislations and responsible practices towards the environment and society Kastenhofer (2010). The survival of this profession can therefore be attributed to its ability at 'adjusting its accustomed approach' (Carew and Mitchell, 2001, p. 1).

The need for sustainability competent engineers is at its greatest point at present, given the growing environmental, economic and societal concerns we globally face at a rapid rate. The profession has been under immense pressure to make fundamental adjustments to its approach, resulting in a paradigm shift for the profession (Thom, 1996, Clift, 1998, Mitchell, 1999). The reorientation envisioned is for the profession to move from being development engineering driven, to sustainable development engineering driven. Therefore, to be in the forefront of the creation of sustainable engineering technology and become change agents of sustainability, engineers of the present need to be well equipped with the knowledge, values and skills necessary for them to be able to contribute towards the goals of sustainability.

According to Carew and Mitchell (2001), the development vs. sustainable development shift in paradigm for the profession has been well received by key stakeholders of the engineering profession. In aiding the implementation of these goals, many engineering bodies throughout the world have made it compulsory for their engineers and engineering graduates to possess the skills and knowledge to efficiently work with sustainability. Byrne's (2010) study for instance highlights significant initiatives undertaken by engineering bodies over the world in advocating for sustainable development within the profession's professional practice and code of ethics. Byrne's (2010) findings on the integration of sustainable development, although thorough, are concentrated upon activities within the engineering profession in Australia, Canada, the United States and the United Kingdom.

The practice of sustainable development and sustainable engineering is not solely practiced within the western engineering context. Engineering organizations in Asia have also come to integrate sustainability as an integral goal of its professional ethics. Engineering organizations in India, Singapore and Malaysia are some of these engineering organizations that have incorporated sustainable engineering guidelines within its professional guidelines. In India, five guidelines have been put forth by the Institution of Engineers, in acknowledgment of the central role engineers have in sustainable development. These guidelines are, 'concern for ethical standards, concern for social justice, social order and human rights, concern for protection of the environment, concern for sustainable development and public safety and tranquillity' (Institution of Engineers India, 2013). In Singapore, the Institution of Engineers Singapore list social responsibility as one of the four core values its engineers should possess (Institution of Engineers Singapore, 2013). In Malaysia, the Institution of Engineers and the Board of Engineers stress the need for Malaysian engineering graduates to be able to integrate sustainable development in their professional practice, as apparent in the institution's code of practice.

The sustainable engineering initiatives highlighted above are an indication of the engineering industry's concerted efforts in making sustainable development an integral part of the profession. Undertaken worldwide, these initiatives are evidence of the engineering industry's positive response to sustainable development. Malaysia's acknowledgement of the significance of sustainable engineering is evidence of the importance the national engineering bodies and the nation place on sustainable development.

1.1.2 Sustainable development and sustainable engineering in Malaysia: Implications for undergraduate engineering education programmes

This section highlights perspectives of the Malaysian engineering industry on sustainable development and sustainable engineering. Also discussed are the implications of the Malaysian engineering industry's perceived views of sustainable development and sustainable engineering and its implications for undergraduate engineering programmes offered by higher learning institutions in the country.

In 2009, a study was carried out to look into the views of the Malaysian engineering industry employers on the present and expected competencies of the country's engineering graduates. Employers feedback were sought on 13 competencies, namely (a) 'ability to acquire and apply knowledge of engineering fundamentals, (b) theoretical and research engineering, (c) application and practice oriented engineering, (d) communicate effectively, (e) in-depth technical competence in a specific engineering discipline (f) undertake problem identification, formulation and solution, (g) utilise a systems approach to design and evaluate operational performance, (h) function effectively as an individual and in a group with the capacity to be a leader or manager as well as an effective team member , (i) understanding of the social, cultural, global and environmental responsibilities and ethics of a professional engineer and the need for sustainable development, (j) recognising the need to undertake lifelong learning, and possessing/acquiring the capacity to do so, (k) design and conduct experiments, as well as to analyse and interpret data, (l) knowledge of contemporary issues, and (m) basic entrepreneurial skills' (Azami Zaharim et al., 2009, p. 411). The detailed findings of the study are illustrated in Table 1.1.

Table 1.1: Summary of main findings

Item	Competency	Current level of competency	Expected level of competency
1	Ability to acquire and apply knowledge of engineering fundamentals	54.3%	83.6%
2	Having the competency in theoretical and research engineering	47.4%	73.2%
3	Having competency in application and practice oriented engineering	52.4%	85.5%
4	Ability to communicate effectively, not only with engineers but also with the community at large	49.5%	86.7%
5	Having in-depth technical competence in a specific engineering discipline -	48.8%	82.5%
6	Ability to undertake problem identification, formulation and solution	48.1%	84.6%
7	Ability to utilise a systems approach to design and evaluate operational performance	55.7%	78.9%
8	Ability to function effectively as an individual and in a group with the capacity to be a leader or manager as well as an effective team member	55.7%	85.1%
9	Having the understanding of the social, cultural, global and environmental responsibilities and ethics of a professional engineer and the need for sustainable development	51.2%	80.3%
10	Recognising the need to undertake lifelong learning, and possessing/acquiring the capacity to do so	49.3%	80.1%
11	Ability to design and conduct experiments, as well as to analyse and interpret data	42.4%	74.6%
12	Having the knowledge of contemporary issues	47.9%	75.4%
13	Having the basic entrepreneurial skills	24.4%	57.6%

(Azami Zaharim et al., 2009b: p. 411 - 414)

As presented in Table 1.1, findings on engineering graduates present level of competencies indicate that only five out of the 13 competencies listed a satisfaction level of 50% and more. Competence 7 and 8 recorded the highest percentage at 55.7% each, while the lowest was recorded for competence 13 at 24.4%. These percentages are considered rather low, and suggest that engineers need to improve significantly in areas listed. As for the expected level of competencies, communicating effectively was listed as the competency most expected of Malaysian engineers, while least expected was entrepreneurial ability.

In terms of sustainability competencies within the profession, only 51.2% of the employers were satisfied with their engineers' present abilities in understanding 'social, cultural, global and environmental responsibilities and ethics of a professional engineer and the need for sustainable development' (Azami Zaharim et al., 2009b: p. 411). This shows that almost half of the 422 employers surveyed thought their employees lacked this competence. Additionally, 80.3% of the employers also indicated that they expected their engineers to be sustainability competent. It is nevertheless equally interesting to note that 19.7% of the employers believed that sustainable development was unimportant.

While the Board of Engineers and Engineering Accreditation Council of Malaysia promote the need for sustainable engineering practices, interestingly, perspectives of the Malaysian engineering industry employers seem to suggest otherwise. These findings are significant, as it suggests that Malaysia's engineering education programmes are not adequately preparing its graduates to be sustainability competent. It also indicates a serious mismatch between the expectations of the industry of its engineers, and the quality of sustainability competent graduates produced by local universities.

Mustafa et al. (2008) conversely investigated views of the employees, i.e. engineers who were working in the electronics sector. The study was conducted to ascertain their perceptions on important attributes for Malaysian engineers to be equipped with. The findings of this study suggest (i) competent communication skills, (ii) the ability to lead and manage, (iii) interest in engineering practice, and (iv) have basic awareness of the engineering profession were the key attributes for Malaysian engineers to develop (Mustafa et al., 2008). Interestingly, the study did not look into engineers' perceptions on sustainable development as an attribute for engineers to have or to cultivate.

These two studies indicate a pertinent issue, i.e. a critical mismatch between the sustainable development goals envisioned by the engineering bodies and that of the engineering workforce employers and employees. The disparities that exist between the desired sustainable engineering outcomes and the actual sustainable engineering outcomes set within the Malaysian engineering workforce are thus worrying. As of April 23rd, 2014, a total of 74601 graduate engineers have registered with the Board of Engineers, Malaysia. This is a strong indication that engineers who have graduated from engineering programmes offered by Malaysian universities make up a significant number of the engineers in the Malaysian engineering workforce. As such, when a significant number of the Malaysian engineering workforce employers and employees deem sustainable development awareness as irrelevant, it becomes evident that more appropriate measures need to be implemented at Malaysian universities to develop graduate engineers who are more empathetic to sustainable development and sustainable engineering.

In ensuring sustainable development outcomes are appropriately addresses within an engineering programme, a reorientation of the programme's educational philosophies is essential. Similar propositions were also advocated by Orr (1992, 2004). In Malaysia, outcome based educational approaches are used as the corner stone for teaching and learning practices within engineering education. Measurable outcomes are developed at three levels, namely the programme objective level, programme outcomes level and course outcomes level. It also emphasises the need for programme outcomes to be centered on the knowledge, skills and attitudes engineering students need to attain during their studies and upon graduation. Outcome based education is centered on the needs of students and stakeholders.

For sustainable development outcomes to be appropriately addressed within Malaysian undergraduate engineering programmes, it is important that the current outcome based approach for engineering education is re-positioned within an ESD lens, using a holistic, whole institution approach imbued within transformative educational principles. The potential of this re-positioning is immense, given the similarities between teaching and learning approaches advanced by outcome based education, ESD[1] and transformative education.

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[1]There have been many terms used to describe education which focuses on sustainability, i.e. education for sustainability and sustainability education. These terms can be used 'synonymously and interchangeably' (McKeown, 2002), although the term ESD is the term most widely used, especially within United Nations documents (McKeown, 2002). The term ESD, will be used for the purpose of this study.

It is also important to note that the incorporation of ESD as programme outcomes and module learning outcomes within the engineering curriculum cannot be a simple insertion to main sections of the curriculum, but rather to the engineering programme as a whole. Recent developments in ESD also indicate a notable paradigm shift in embedding sustainability within the curriculum, i.e. from being solely technical to being driven by the social sciences and the humanities as well. The manner in which sustainable development outcomes should to be integrated within a curriculum is a further issue that has sparked much debate within academia. If sustainable development is to be addressed fittingly within the Malaysian engineering curricula, the need for a framework that thrives within scientific and humanistic angles is therefore crucial. As such frameworks are currently limited, developing a framework for engineering education that incorporates engineering, language/ communication, management, social science and humanities perspectives would be advantageous for institutions wishing to incorporate ESD goals or assess the extent to which ESD goals are incorporated within their engineering programmes. The aims of the research are explained in greater detail in the section that follows.

1.2 Research Aims

This research intends to describe, explore and compare higher education stakeholders' (i.e. students, academicians, university management and engineering industry) perspectives and beliefs on the manner in which sustainable development competences can be incorporated within the Malaysian undergraduate engineering education curriculum. Two contributions are expected from the study, i.e. (i) module specific learning outcomes to develop sustainability competences amongst undergraduate engineering students and (ii) a stakeholder defined engineering education for sustainable development (EESD) framework for undergraduate engineering education programmes. Both contributions can be used as integration and evaluation guides by institutions of higher learning that wish to incorporate or assess the extent to which EESD goals feature in their engineering programme outcomes, module learning outcomes and the institution as a whole.

1.3 Research Questions

This section lists the research questions developed for the study.

1. To what extent is sustainable development and ESD incorporated within the engineering curriculum of the higher learning institution?

2. What are the stakeholders perspectives in terms of :

a) the inclusion of sustainable development content within the undergraduate engineering curriculum?

b) the inclusion of the hypothetical sustainable development competences in the curriculum?

c) the new sustainable development competences that should be incorporated in the curriculum?

d) how sustainable development and ESD competences should be incorporated within the curriculum?

3. Based on the stakeholders' views, ESD experts' reviews, ESD practitioners' views and literature on ESD, what should the additional components of the EESD framework for Malaysian undergraduate engineering education be?

1.4 Significance of the study

Malaysia's commitment to sustainability is certain, given the various initiatives put in place by the government to ensure its success. Of significant importance though, is the nation's goal for its human capital to be sustainability competent. The Malaysian Higher Education sector has thus a crucial role to play in realizing the nation's sustainability goals, given the fact that a significant fraction of its human capital are products of the country's higher education system.

With these developments in tow, engineering education in Malaysia has an essential role in ensuring the aspirations of the Ministry of Higher Education to produce human capital of calibre, are in line with the nation's goals for a sustainability competent human capital. With Malaysia now becoming a signatory member of the Washington Accord, there is even a greater need for engineering programmes in Malaysia to be at par or better than engineering programmes offered by other countries that also have membership in the Washington Accord. The incorporation of ESD philosophies through transformative pedagogies would thus propel Malaysian engineering education to greater heights.

This study is significant at national and international levels. At the national level, the EESD framework aimed through this study is timely, given the nation's emphasis for the development of a sustainability competent workforce. The findings of this study will therefore be instrumental to the Ministry of Education, especially in formulating sustainability related higher educational philosophies and guidelines for public and private institutions of higher learning in the country.

The findings will also be beneficial to institutions of higher learning in Malaysia that offer engineering programmes, as it would allow university administrators and academicians make informed decisions on the curricula, pedagogical and institutional aspects that need to be revisited or expanded within the institutions goals, academic programmes and learning modules, so the incorporation of EESD would be a possibility.

At the international level, Malaysia's signatory membership in the Washington Accord has made engineering education in Malaysia at par with countries such as the United States, United Kingdom, Canada, New Zealand, Australia, South Africa, Ireland, Japan, Korea, Singapore, Chinese Taipei and Hong Kong. Findings of this study would be advantageous to the Engineering Accreditation Council of Malaysia as it could enable the organization to develop holistic EESD guidelines and policies that are globally accepted.

1.5 Scope of the study

This study adapted a case study approach. It was carried out at a Malaysian private university which offers undergraduate engineering programmes. The study focused on the undergraduate engineering programmes offered in the university, given its aims. Given the nature of the study, the primary research participants were those directly involved as stakeholders of the university. They were the academicians, members of the university's management team, final year undergraduate engineering students from the university's civil engineering, mechanical engineering, chemical engineering, electrical and electronics engineering and petroleum engineering departments and engineers from the Malaysian engineering industry. Perspectives of ESD experts and practitioners were also sought to better understand the present ESD landscape.

1.6 Organisation of the Thesis

There are a total of eight chapters in this thesis. Chapter 1 starts with an introduction section, followed by a section on the background of the study, the research aims and research questions and the significance of the study. The list of terms used in the study is also defined.

Chapter 2 discusses the theoretical orientation the study is framed upon. The chapter begins with an overview of ESD, and elaborates upon ESD within the context of higher education and engineering education. Existing ESD frameworks and research on ESD are also described and discussed. The focus is then set on ESD research in Malaysia to establish the gap this study seeks to bridge. The chapter also highlights developments in transformative learning, which serves as the pedagogical basis of the study.

Chapter 3 discusses the methodology employed for the study. The chapter begins with a brief introduction to mixed methods research. The discussion then revolves around the mixed methods design used in the study. This is followed by a discussion of the different types of data collection procedures used in the study, namely surveys, interviews, expert reviews and the analysis of documents. The ethical issues associated with the study are also highlighted. Following this is a section on the description of University X, where the study took place. The respondents of the research are also described in this chapter. Chapter 4 explains in detail the quantitative and qualitative data analysis and results of the study.

Chapters 5 to 7 address the discussion of the findings of the study. In these chapters, the quantitative and qualitative findings obtained from the process of data analysis are converged to answer the research questions. Chapter 8 provides the limitations and contribution of the study. Also included are recommendations for future research.

1.7 Definition of terms

This section defines the terms used in the chapters of this thesis. These terms, and its definitions are as presented below:

a. *Sustainable Development competences*

   The United Nations Economic Commission for Europe (UNECE) officially defines sustainable development competence as an individual's ability to contribute to sustainable living within professional and personal capacities.

b. *ESD competences*

   The United Nations Economic Commission for Europe (UNECE) formally defines ESD competences as an educator's ability to assist students in developing sustainable development competence using innovative teaching and learning approaches.

c. *Sustainability competences*

In this thesis, the term *sustainability competence* has been used when describing sustainable development competences and ESD competences.

d. Holistic

The term *holistic* is commonly used when describing different perspectives in an inclusive manner. In this thesis, the term is used when describing the sustainable development competence category guidelines and EESD framework.

e. Sustainable education

Sustainable education focuses on meaningful, engaging and participative forms of learning. It promotes transformative forms of learning which is constructive and engages students in making meaning of their learning experiences. Sustainable education engages in interdisciplinary, multidisciplinary and transdisciplinary teaching within an environment that integrates environmental, social, political, economic and cultural dimensions, from a whole systems perspective.

f. Whole systems

Whole systems is defined as a means of 'thinking and being' to shift past analytic, linear and reductionists mechanistic forms of education. From the perspective of learning, the whole systems approach, also known as the whole institution approach, 'seeks to see connections, relationships and interdependencies to view the whole instead of the parts, but also to understand that intervening in one part of the system can affect not only the other parts but the whole system' (UN Decade of ESD Monitoring & Evaluation Report, 2012: p.28). Sustainable development, within a whole institution approach should permeate within the institution's operations, mobility, curriculum pedagogy and engagement with its stakeholders.

g. Hypothetical ESD competences

The hypothetical ESD competences are the list of 30 competences developed by the researcher. It refers to sustainable development competences engineering students need to be exposed to, to enable them to practice, appreciate and understand sustainable development upon graduation.

h. Programme educational objectives

The Malaysian Engineering Accreditation Council, in its 2012 accreditation manual defines programme objectives, (or programme educational objectives as it is referred to in the university in which this research took place) as specific educational goals which are in line with the vision and mission of the institution of higher learning (Malaysian Engineering Accreditation Council, 2012). Programme objectives are in reference to the career and professional undertakings the engineering programme is preparing its graduates for, three to five years after graduation (Malaysian Engineering Accreditation Council, 2012).

i. Programme outcomes

Programme outcomes are defined by the Malaysian Engineering Accreditation Council as statements that describe what students are able to know, perform or attain by the time they complete their studies (Engineering Accreditation Council, 2012). Types of outcomes include knowledge outcomes, skills outcomes and attitude outcomes.

j. Module learning outcomes

Module refers to a subject taken by students within an engineering programme, e.g. *Engineers in Society* or *Professional Communication Skills*. Module learning outcomes are statements that describe what students are able to know, perform or attain by the time they complete a module.

k. Common modules

Common modules refer to the modules undergraduate engineering students have to complete during the duration of their studies at the university. Common modules include common engineering modules, university requirement modules and national requirement modules. Common modules are general to all engineering programmes. Hence, these modules are not tailored to meet specific engineering programme outcomes of a specific engineering programme.

l. Common engineering modules

Common engineering modules refer to six modules which have to be taken by all undergraduate engineering students in order to graduate from their respective engineering programmes. The common modules referred to in this thesis are *Health, Safety & Environment*, *Engineering Economics & Entrepreneurship*, *Engineers in Society*, *Engineering Team Project*, *Probability & Statistics* and *Introduction to Management*.

m. Non-engineering modules

Non-engineering modules are in reference to language and communication, business and management, social science and humanities modules taken by the undergraduate engineering students during their course of study at the university.

n. Stakeholders

Stakeholders refer to an individual or a group of individuals who have interest in a particular outcome. In this study stakeholders refer to final year undergraduate engineering students, academicians, the university's management and employers of the engineering industry. The ESD practitioners and ESD experts are not stakeholders but their views are used as an added dimension to the study.

1.8 Conclusion

The aim of this chapter has been to provide the background, significance and aims of this study. The chapter also highlighted the research questions and intended output of the study, i.e. an ESD evaluation and integration guide. The next chapter will highlight the theoretical orientation of the study, in addition to discussing the research gap this study intends to bridge.

CHAPTER 2

THEORETICAL ORIENTATION & REVIEW OF LITERATURE

PART 1: ESD WITHIN THE HIGHER EDUCATION CONTEXT

2.0 Introduction

Chapter 2 extends the discussion presented in Chapter 1, focusing on pertinent issues in relation to the framing of the theoretical orientation of the study. Issues highlighted include the place and role of sustainability within the broader context of higher education, EESD, sustainable development competences as well as pedagogies for ESD. Also discussed are previous studies upon which the case for the present study has been developed.

2.1 Education for Sustainable Development (ESD)

ESD is an expanding field. While it has been associated with other sustainable development related education, its relationship is strongest to environmental education, as it is seen to add on to its goals (UNESCO, 2013). Environmental educationists are said to be the first to support ESD. However, present support for ESD is seen in most fields of study, i.e. engineering, medicine, education, business, geography and language studies, to name a few. The foremost goal of ESD is the development of a populace equipped with the knowledge, skills and values to support behaviour which is sustainable, civic engagement and a better quality of life (UNESCO, 2005; Kevany, 2007).

ESD was first introduced through Agenda 21, the first international document that recognized the importance of education as a means of promoting and developing sustainability. Since then, there have been many terms used to describe education which focuses on sustainability, i.e. ESD, education for sustainability and sustainability education. Notes McKeown (2002), however, the term ESD is most extensively used, particularly in United Nations documents. The term ESD will also be used in the present study.

UNESCO (2006) defines ESD as a goal of education that aims to balance societal, environmental economic and cultural traditions for the preservation of the earth's wealth. ESD is transdisciplinary based and advocated lifelong learning. UNESCO envisions ESD as an overarching embodiment for the various forms of education. It advances the means to re-imagine educational programmes and systems in relation to methods and contents to enable the support of a sustainable society. The four thrusts of ESD stipulated by UNSECO are 'improving access and retention in quality basic education, reorienting existing educational programmes to address sustainability, increasing public understanding and awareness of sustainability and providing training' (UNESCO, 2013). While UNESCO's definition of ESD is widely used in literature, other descriptions for the term also exist. The UK Sustainable Development Education Panel definition is highlighted as an instance, given its competence focused delineation. Knowledge, skills and values, additionally, are akin to literacies associated with sustainability.

> 'ESD enables people to develop the knowledge, values and skills to participate in decisions about the way we do things individually and collectively, both locally and globally, that will improve the quality of life now without damaging the planet for the future'.
>
> (UK Sustainable Development Education Panel, *First Annual Report,* in Sterling, *1998*: p. 30)

Sustainable development competences are an indispensable component of ESD, and will be explored further in this chapter. As the present study is set within the higher education backdrop, an understanding of ESD within the higher education context is also essential. Following this is a discussion of undergraduate engineering education in Malaysia.

2.2 Contextualizing ESD

In the previous section of this chapter, definitions and characteristics of ESD were made clear. As the present study focuses on ESD from the perspective of higher education, the need to establish the link between these entities is deemed essential. It is thus the aim of this section to make this link more lucid.

2.2.1 Higher education and ESD

> 'Higher education institutions bear a profound, moral responsibility to increase the awareness, knowledge, skills and values needed to create a just and sustainable future. Higher education plays a critical but often overlooked role in making this vision a reality. It prepares most of the professionals who develop, lead, manage, teach, work in, and influence society's institutions'. (Cortese, 2003: p.17)

Higher education plays a significant role in developing the ESD agenda. The quote from Cortese above elucidates this point. Historically, the advent of sustainable development in higher education can be traced to the 1990s, following efforts such as the *Talloires Declaration*, the *Kyoto Declaration on Sustainable Development* and the *University Charter for Sustainable Development*. The *Talloires Declaration* carried signatories' pledge 'to establishing programmes for environmentally responsible citizenship, to teaching environmental literacy to all undergraduate, graduate, and professional students, and to developing interdisciplinary approaches to curricula, research initiatives, operations, and outreach activities' (Jones, Selby and Sterling, 2010: p. 3). Through the *Kyoto Declaration on Sustainable Development*, it was agreed upon that universities would 'develop university capacity to teach, research, and take action according to sustainable development principles, to increase environmental literacy, and to enhance the understanding of environmental ethics within the university and with the public at large' (Jones, Selby and Sterling, 2010: p. 3). Also proposed was the need for sustainability to be included in the curriculum, teaching and learning activities of universities. Despite varied reactions, these declarations mark some of the key sustainable development educational milestones. Besides these, five other declarations have also made an impact on the promotion of sustainability. These include the Thessaloniki Declaration, the World Declaration, the Earth Charter, the Lüneburg Declaration, and the Ubuntu Declaration (Byrne et al, 2010).

A further evidence of the significance of higher education in bringing the sustainable development agenda to the fore is Agenda 21. Agenda 21 was developed to promote the importance of ESD. Despite its aims, Agenda 21 was viewed as a 'typical modernist position which associates ESD with a transfer of scientific and technological knowledge and considers education to be a means for placing human potential, as other forms of potential, in the service of economic growth' (Sauvé, 1999: p.25). Similarly, Huckle (1999) was also of the opinion that the initiative was merely an attempt at a 'greening of capitalism' and a feeble version of sustainable development.

The role of higher education in promoting sustainable development was formally constituted when the United Nations General Assembly declared the years 2005-2014 the Decade of ESD (DESD). Through the Decade of ESD, higher education was tasked with playing a significant role in bringing forth the sustainability agenda. UNESCO was chosen as the lead organization for the worldwide execution and synchronization of the Decade of ESD. As stipulated in the Draft International Implementation Scheme,

> 'Universities must function as places of research and learning for sustainable development... Higher education should also provide leadership by practicing what they teach through sustainable purchasing, investments and facilities that are integrated with teaching and learning…Higher education should emphasize experiential, inquiry-based, problem-solving, interdisciplinary systems approaches and critical thinking. Curricula needs to be developed, including content, materials and tools such as case studies and identification of best practices'.

(UNESCO, 2005, p. 22-23, in Jones, Selby and Sterling, 2010: p. 2)

June 2012 marked another key milestone for sustainable development and higher education. Rio 2012, the United Nations Conference on Sustainable Development, witnessed the higher education community's renewed commitment to sustainable development. A five point action plan was agreed upon by over 250 leaders of higher education institutions for the international quest for sustainable development (United Nations Global Compact, 2012).

In discussing sustainable development within the context of higher education, Leal Filho (2009) is of the opinion that universities have a responsibility towards their students, faculty and staff to not only develop skills that are essential to move ahead effectively in a globalised world, but also to instil in the university community a positive attitude towards environmental issues. Interestingly, research conducted by Corcoran and Wals (2004) indicate that the extent of the negative influences of university graduates to the ecosystem is incomparable. These findings therefore imply that higher education has the added responsibility of engaging in more conscious efforts to prepare its graduates to embrace sustainable development, as observed by Cortese (2003) and Leal Filho (2009). The higher education community's commitment to sustainable development, witnessed through these various declarations, and the most recent Rio 2012 action plan, is an encouraging indication of the growth of sustainable development within higher education. The five themes covered in the action plan i.e. teaching, research, institutional practice, community development and engagement also suggests the higher education community's holistic approach to sustainability, as the areas covered in the action plan reflect core beliefs of sustainability.

While these initiatives are lauded, it is nevertheless felt that attention should also be drawn to the system within which ESD operates. Davis and Cooke (2007) for instance, assert that if learning occurs in an educational system based on educational views that 'sustain unsustainability' it can contribute significantly towards the issue of re-production of unsustainability. Also fundamental are the principles of the organisation, which needs to emphasise upon the creation of change that is transformational (Sterling, 2004). Additionally, Capra (2000) believes that the unsustainable mentality presently showcased can be reverted through the redesign of current technologies and social institutions through the application of ecological understanding and systemic thinking. Similarly, Martin and Murray (2010), urge higher education to're-think' its teaching and learning methods. Research conducted by Jucker (2011) indicates that there is a reproduction of unsustainability by the present systems of education. Also evident was the issue that the finest education of the present day is unfavourable for the future prospect of the planet. Findings of his study also suggest that there is an essential need for education to be redesigned, from a systemic perspective.

The section that follows explores the above issues further, through a discussion of ongoing efforts and issues faced by universities in implementing sustainable development within their institutions.

2.2.2 Strategies, barriers and reactions towards the implementation of sustainable development within higher education

The majority of research on implementing sustainable development within the higher education context can be divided into areas such as (i) frameworks or models for the implementation of sustainable development within the curriculum or institution of higher learning and (ii) strategies, barriers and reactions towards the advancement of sustainable development within university policies and practices. According to Armstrong (2011), most higher education initiatives on sustainability have mostly revolved around campus greening and research. Research also indicates that the inclusion of ESD has been slow in the context of higher education, (Bossellmann, 2001; Everett, 2008; Rode & Michelsen, 2008). Pedagogical based research initiatives, while apparent, have not developed as rapidly as it should (Sterling & Scott, 2008; Cotton, et al., 2009; de le Harpe & Thomas, 2009; Wals, 2009).

The review of literature discussed in this section will encompass two of the three areas mentioned above, namely research on frameworks and models and research on strategies, barriers and reactions towards the implementation of sustainable development in higher education. The review of pedagogies for ESD will be included in the section of this chapter devoted to competences.

2.2.2.1 Frameworks and models for the implementation of sustainable development within the curriculum or within the institution

This section looks at some of the framework and models presently available for the advancement of sustainable development within the higher education context. The need for a Malaysian EESD framework is established at the end of the section.

2.2.2.1.1 Auditing Instrument for Sustainability in Higher Education (AISHE) Framework

The Auditing Instrument for Sustainability in Higher Education (AISHE) framework was developed by the Dutch National Working Group on Criteria on a request by the Dutch Committee for Sustainable Higher Education. According to Roorda (2001), the AISHE can not only be used by institution of higher learning, but by secondary schools as well. Assessment fields covered in the AISHE framework include vision and policy, expertise, educational goals and methodology, education contents and result assessment.

The Sustainability Tracking Assessment and Rating System (STARS) is another framework that is widely used to assess sustainability in the higher education context. The STARS framework was developed by the Association for the Advancement of Sustainability in Higher Education, which is an association of colleges and universities with goals to empower higher education to be in the forefront of sustainability (AASHE, 2012). Assessment fields include education and research, operations, planning, administration and engagement and innovation. The AISHE and AASHE frameworks can be used for the implementation of sustainable development within the curriculum or within the institution. While both frameworks can additionally be used as audit instruments for higher learning institutions to assess sustainability and ESD goals as it covers a wide range of criteria, sustainable development educational goals and learning outcomes are not extensively detailed.

2.2.2.1.2 The Four C Model

The University of Plymouth in the United Kingdom developed the 4C model to integrate sustainable development within its institution holistically. The 4Cs in the model are linked and are representative of the curriculum, campus, community and culture. The model advocates a curriculum that is both disciplined based and interdisciplinary. Sustainability is further embedded within the university's estate practices, links with the community as well as institutional norms and practices, which is represented by the model's campus, community and culture elements (Jones, Selby and Sterling: 2010).

2.2.2.1.3 The Five C Model

The 5C model is another example of a holistic model developed by the University of Nottingham. The 5Cs in the model represent the curriculum, community, campus and contribution (University of Nottingham, 2013). At the heart of the model is the element of culture.

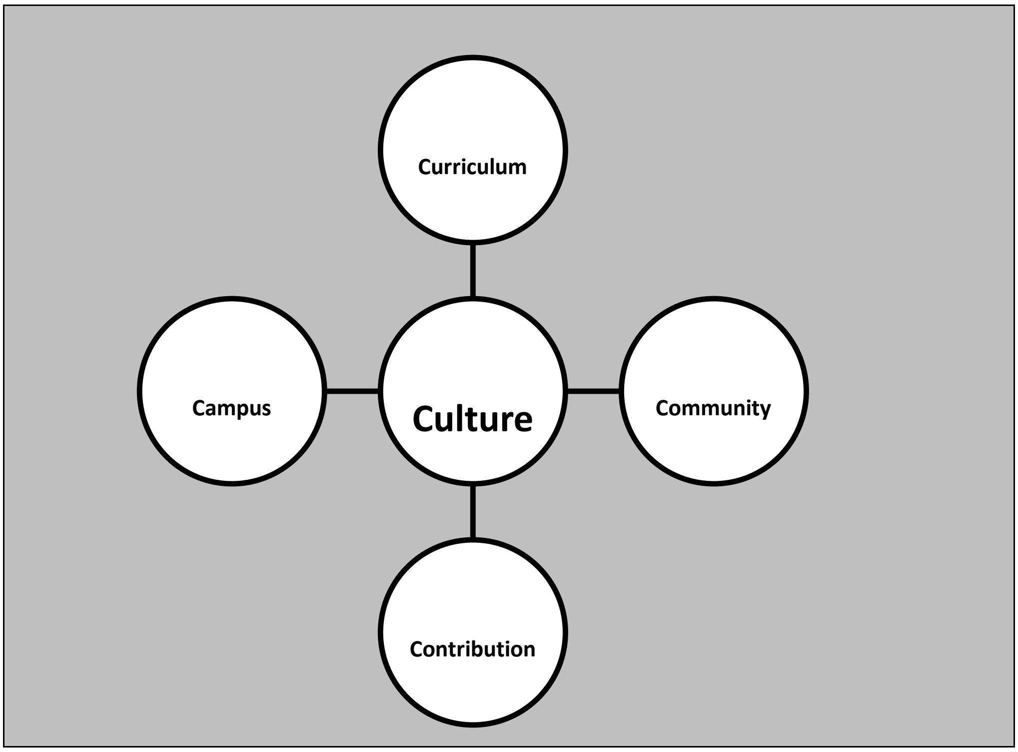


Figure 2.1: The curriculum, campus, community, contribution and culture model

2.2.2.1.4 Sustainability DNA model

The University of Gloucestershire in the United Kingdom developed a Sustainability DNA model as a strategy to embrace sustainable development as a strategic priority. The Gloucestershire Sustainability DNA is holistic in nature and encompasses six elements. These are operations, outreach, student experience, teaching and learning, research and management and support (University of Gloucestershire: 2013).

2.2.2.1.5 The Framework, Levels and Actors Framework

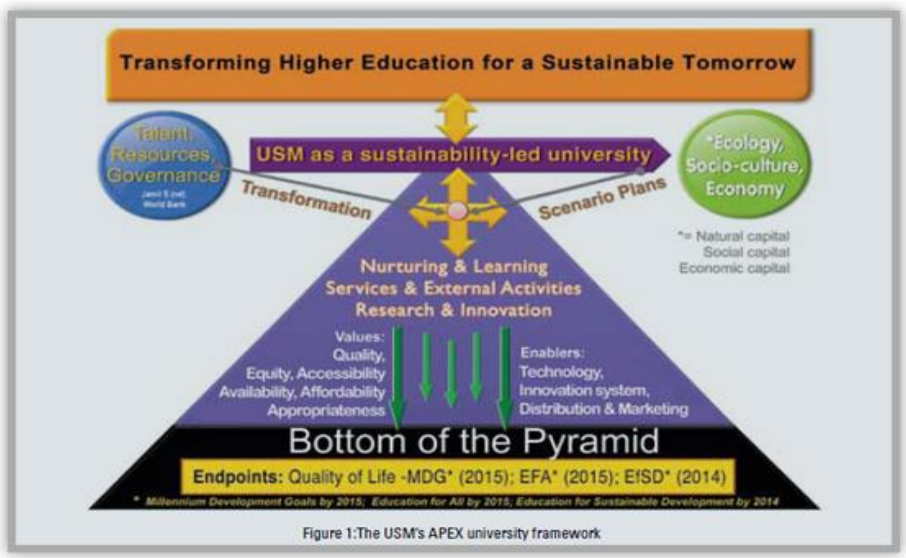
The next framework is the Framework, Levels and Actors Framework (FLA). Ferrer-Balas, Buckland and de Mingo (2009) highlight the important role played by a university in society for sustainable development. Using a systems transition approach and built upon the Framework, Levels and Actors (FLA) conceptual framework, their study investigated the Technical University of Catalonia's role in society for sustainable development against four areas, namely interaction and social commitment, research, education and management.

2.2.2.1.6 The Integral University model

A 2004 study conducted by Ferrer-Balas, Bruno, de Mingo and Sans at the Technical University of Catalonia in Barcelona, Spain indicates that the inclusion of environmental aspects in technical education can be done through an 'integral university approach' which merges concurrent action in education, research, university life and communication for the development of a model that is synergetic. In expediting the change of the university towards a sustainable one, the research indicates the significance of approaches such as the creation of useful tools for decision making, the introduction of environmental indicators into university processes and assessment of change through environmental research maps.

2.2.2.1.7 Accelerated Programme for Excellence (APEX) Framework

In the Malaysian forefront, the National Science University (USM), a public university, has been committed to sustainable development endeavours. The university was accorded the Accelerated Programme for Excellence (APEX) status by the Ministry of Higher Education in 2008 for its commitment to issues such 'a sustainable world, humanity and the future of the humankind' (USM, 2012). The university's APEX framework, sourced from its website, clearly indicates sustainability as a key driver for the university. The APEX framework places emphasis on the elements such as 'embracing ecological protection, conservation of resources and human development based on the virtues of equity, accessibility availability, affordability, appropriateness and in articulating a wholesome meaning of quality' (USM, 2012). The APEX framework reflects a general framework for the transformation of the institution to strengthen its main mission, i.e. 'a pioneering university, transdisciplinary and research-intensive that empowers future talents and enables the bottom billions to transform their socioeconomic well-being' (USM website, 2012). The framework however does not clearly illustrate the manner in which sustainable development outcomes can be incorporated within its academic programmes.



(USM, 2012)

Figure 2.2: The APEX framework

Although the frameworks discussed in this section have been developed by various universities using different educational philosophies and cultures, several commonalities are nevertheless apparent between the elements within these frameworks. The curriculum, campus, community and research are the evident similarities between these frameworks. This likeness across the various universities is an indication of the importance of these four aspects within university practices and operations. The framework and models presented represent whole system frameworks which focus on the integration of sustainable development across the university. These frameworks and models do not focus on a specific feature of an institution of higher learning, i.e. curriculum, or policy or research, but encompasses a broader outlook. The whole systems approach, which is also known as the whole-institution approach has increasingly become an important mechanism to advance sustainable development across the whole institution of higher learning given its benefits in synchronizing learning with the manner in which the institution operates. Another advantage of the whole institution approach is its efforts in engaging multiple stakeholders of the institution in making joint decisions about the institution's operations and processes (UN Decade of ESD Monitoring & Evaluation Report, 2012).

In continuation of the discussion on frameworks for the integration of sustainable development within institutions of higher learning, the sections that follow discuss sustainable development frameworks at the curriculum level which focus on instruction, learning outcomes and delivery of sustainable development content.

2.2.2.1.8 ESD Generic Learning Outcomes Framework

This ESD framework was developed in 1998 for the Panel for ESD, UK. This is a framework which addresses sustainability educational goals and learning outcomes elaborated through values, skills and understanding, which are the key elements of ESD. The ESD framework is drawn upon seven key concepts of sustainable development, which inform the curriculum of ESD in the UK, namely, (a) 'Interdependence - of society, economy and the natural environment, from local to global, (b) Citizenship and stewardship - rights and responsibilities, participation, and cooperation, (c) Needs and rights of future generations, (d) Diversity - cultural, social, economic and biological, (e) Quality of life, equity and justice, (f) Sustainable change - development and carrying capacity, (g) Uncertainty, and precaution in action'(Sterling, 1998: p.5). While it can be argued that this framework was developed to address sustainability education goals within the context of United Kingdom, it must be pointed out here that these concepts encompass key global sustainability concerns which are advocated by nations around the world. This framework could also be adapted to develop an ESD curriculum for the Malaysian context.

2.2.2.1.9 Learning and sustainability framework

Scott and Gough's (2003) learning and sustainability framework emphasises the importance of learning to establish the bond between the environment and humanity. The framework emphasises the need for a close relationship between society, learning and sustainability. It also includes 'serendipitous and accidental learning' (p. 38) in which the principle concern is with what students gain knowledge of, and not what educators instruct. Information (instruction of learners), Communication (engagement of learners) and Mediation (facilitation of learning) are the three strategies through which learning takes place. These strategies are interrelated and have an impact upon education and training. Learning takes place independently of the actions of educators and policy makers due to external factors (either positive or negative) such as economic policy, social policy, legal context and change, development of civil society, technological innovation, and demographic change.

2.2.2.1.10 Curriculum Greening of Higher Education model

In a study conducted by Junyent and de Ciurana (2008) on education for sustainability in university curriculum involving 11 European and Latin American universities, the Curriculum Greening of Higher Education model or ACES (Spanish acronym) was developed with the following characteristics: 'Integrating the paradigm of complexity into the curriculum, Introducing flexibility and permeability into disciplines, Contextualizing the curricular project, Taking the subject into account in the construction of knowledge, Considering the cognitive, affective and action aspects of people, A consistent relationship between theory and practice, Working within a prospective orientation of alternative scenarios, Methodological adaptation: new teaching and learning methodologies, Creating space for reflection and democratic participation and Reinforcing the commitment to transforming relations between society and nature' (p. 768-770).

While the FLA and the ACES frameworks point to ways in which sustainability can be integrated within a university, the frameworks may need to be looked into further with regards to its implementation in various educational contexts and cultures. As sustainability is culturally and contextually bound, it would be rather difficult to tell if these frameworks would bring about positive change if used in a non-European cultural and educational context. The frameworks also do not provide much description on the different contextual levels and paradigms in which a university may adapt or adopt sustainability education holistically.

2.2.2.1.11 Sustainability in higher education (SHE) framework

The sustainability in higher education (SHE) framework addresses the issue of the delivery of sustainable development content, through the development of a generic matrix that can be used by academicians to integrate sustainable development within the curriculum (Rusinko, 2010). The matrix is as presented in Figure 2.3.

		SHE delivery	
		Existing structures	**New structures**
SHE focus	**Discipline-specific**	I Integrate into existing course(s) minor(s), major(s), or programs(s)	II Create new, discipline-specific sustainability course(s), minor(s), major(s) or programs(s)

	Cross	III Integrate into common core requirements	IV Create new, cross-disciplinary sustainability course(s), minor(s), major(s), or programs(s)

(Rusinko, 2010: p.252)

Figure 2.3: Sustainability in higher education framework

The SHE matrix contains four quadrants which represent the different options of integrating sustainable development within the curriculum. Quadrant I represents the integration of sustainable development using a discipline-centric focus, within an existing structure, i.e. through a topic, case or module. Quadrant III represents the option of integration of sustainable development using a cross-disciplinary focus, within an existing structure, i.e. through common core courses (Ruskino: 2010). Quadrant II promotes the option of using a discipline-specific focus, through the development of new courses, minors, majors and programmes. Examples include a stand-alone module, a new minor, major or programme. The fourth quadrant represents a cross-disciplinary focus, through the development of introductory cross-discipline courses, minors, majors and programmes. Examples include cross-disciplinary introductory modules or capstone courses (Ruskino: 2010). According to Ruskino, the four quadrants of the matrix have its advantages and disadvantages. The advantage of quadrant I is that it is easy to implement using existing administrative support, while its disadvantages is the inadequate and non-uniform integration of sustainable development. While cross-disciplinarily focus is a major advantage of quadrant III, its high use of resources and administrative support makes its less favourable. The benefits of quadrant II is the development of an independent sustainable development identity within disciplines, and the opportunity to deliver sustainable development content using a more standardized approach within disciplines. Its disadvantage, however, is that it could cost more in terms of resources and administrative support. An independent sustainable development identity across disciplines and greater students' exposure to sustainable development is seen as an important benefit of quadrant IV. Its disadvantage, nevertheless, is its excessive use of resources and administrative support (Ruskino: 2010).

The frameworks and models for the implementation of sustainable development within the curriculum or within the institution illustrated indicate that guidelines are available for the inclusion of sustainable development within the larger context of the higher education institution. There also exist general frameworks for the inclusion of sustainable development within the curriculum. However, there seem to be limited frameworks and models developed to address integration and assessment of sustainable development for specific programmes of study (e.g. engineering, medicine, business, language studies or education specific details) or specific modules within a programme of study. There also seem to be a lack of general frameworks within non Western contexts. These shortcomings indicate that more research is needed within these areas. The development of an EESD framework for undergraduate engineering programmes in Malaysia envisioned by the present study would therefore address these limitations. The next section looks at research focused on the strategies, barriers and reactions towards the advancement of sustainable development within university policies as well as academic and institutional practices.

2.2.3 Advancement of sustainable development within university policies and practices: A discussion of approaches, barriers and reactions

This section presents strategies undertaken by universities in advancing sustainable development within institutional policies as well as academic and institutional practices, and the challenges faced in doing so. Discussions will also encompass the impact of these efforts on students of institutions of higher learning.

2.2.3.1 Barriers and approaches for implementing sustainable development

Literature on the implementation of sustainable development at universities indicates a host of factors that contribute to problems surrounding the integration of sustainable development. Valazquez et al (2005) for instance conducted a study to determine the factors that could hinder the implementation of sustainable development in higher education institutions. A review of engineering, economics, sociology, and science articles, proceedings, institutional reports, books, and website documents written from 1990 to 2002 was conducted for this purpose. The findings of the study indicate a total of 18 factors that deter sustainable development initiatives in higher education institutions. These factors are 'lack of awareness, interest, and involvement, organizational structure, lack of funding, lack of support from university administrators, lack of time, lack of data access, lack of training, lack of opportune communication, and information, resistance to change, profits mentality, lack of more rigorous regulations, lack of interdisciplinary research, lack of performance indicators, lack of policies to promote sustainability on campus, lack of standard definitions of concepts, technical problems, lack of designated workplace, and the Machismo' effect, i.e. women's lack of confidence in leading initiatives (Valazquez et al, 2005: 385).

In the United Kingdom, Ryan's (2011) study identified challenges in addressing ESD in the curriculum. These were, creating an integrated understanding around ESD, developing interrelated approaches across the university and positioning of ESD with the university's teaching and learning functions to enhance the teaching and learning. A study conducted by Martin et al. (2006) on embedding sustainable development in higher education in the UK revealed four obstacles. An overcrowded curriculum, irrelevance of sustainable development as perceived by academic staff, lack of staff awareness and expertise and a lack of institutional drive and commitment were noted as hindrances to the initiative. Similar obstacles are seen in the study conducted by Valazquez et al (2005) and Down's (2006) study of Jamaican trainee teachers, where colleague's scepticism, students' course expectations, content vs. actual course with ESD input, policy absence, and syllabus constraint, were cited as some of the challenges towards making sustainable development mainstream.

Besides these factors, Wells et al (2009), in their case study of the role of academia in regional sustainability initiatives in Cardiff University in Wales, UK, discovered that there was little engagement of universities in regional sustainability initiatives. This was contributed by differing views on political and administrative issues. Leal Filho (2009) further states that institutional sustainability policies, staff and student mobility, staff training, addition of sustainability in research, insertion of sustainability in continuing education and extension are other important challenges faced by universities. Sterling (2011) cites the lack of content boundaries, the use of holistic and interdisciplinary approaches, the issue of ethics and the fact that sustainable development is an issue that is constantly evolving as factors that impede the implementation of sustainable development.

Chun Shi's (2006) study on *Exploring Effective Approaches for ESD in Universities of China* indicates an incomplete environmental education system as a barrier to implementing sustainable development. Outdated curriculum designs, insufficient ESD textbooks and teachers, self-restriction and low environmental consciousness and behaviour were cited as reasons for the incomplete system of education. The emphasis placed on academic achievement in universities was another barrier in developing sustainable development in universities in China. Given the emphasis on academic excellence, sustainable development initiatives which are usually conducted as voluntary activities in universities is seen as insignificant, and therefore receives little support from students.

Mulder and Jansen's (2006) study on integrating sustainable development in engineering education at Delft University of Technology revealed academic culture and organizational issues as major setbacks in carrying out sustainable development initiatives at the university. Issues factored as academic culture include the perception of external forces as a threat to academic freedom, the race for scientific credentials, preservation of strong disciplinary borders and expertise areas and resistance to change in curricula as it is deemed as offensive. Organizational issues include time, the availability of resources and personnel, political processes within the department and being attuned to the demands of industry stakeholders.

In another study on implementing sustainable development for engineers at the University of Technology, Sydney, Bryce et al (2004) found that the faculty structure and a narrow curriculum which failed to promote appreciation for social and environmental contexts for the engineering practice were stumbling blocks to the implementation of sustainable development within the engineering programme at the university. In addition to these issues, the university's emphasis on faculty to win research funding inadvertently led to the establishment of discipline centric research groups instead of interdisciplinary and transdisciplinary research clusters which are seen to be important in sustainable engineering research. The findings of this study bear similarities to the findings of the studies conducted by Valazquez et al (2005) and Mulder and Jansen (2006), indicating discipline centrism, organizational structure and the refusal to shift away from area of expertise as common hurdles to the implementation of sustainable development in engineering and non-engineering programmes in these countries.

Strategies and recommendations to counter the above mentioned challenges are seen as important measures in creating a smoother transition to sustainability in institutions of higher learning. In 2012, a study on turnaround leadership for sustainability in higher education in Australasia, North America, the U.K. and Europe was conducted by the University of Western Sydney, in partnership with The Australian National University and the Sustainable Futures Leadership Academy. The study was conducted in the wake of 'a complex, interlocked and rapidly unfolding set of sustainability challenges underpinned by social, cultural, economic and environmental developments' (Scott et al, 2012: p. 1) faced by the higher education sector. In recognizing that universities' and colleges' efforts in focusing upon the environmental, social, economic and cultural dimensions of sustainable development within teaching, research, engagement and operations, must be led, the study sees the need for higher education to take a leading role in developing future leaders who possess the skills to manage the challenges of sustainability effectively. The study outlines 10 strategies for the systematic implementation of sustainable development in higher education institutions, i.e. (a) ‘acknowledge the distinctive challenges and complexity of education for sustainability (EfS) leadership, (b) sharpen the focus and understanding of EfS as it applies in higher education, (c) context counts: ensure organisational integration and system alignment to support EfS and its leaders, (d) track and improve EfS program quality more systematically, (e) put in place the right incentives, (e) engage the disengaged and the institution’s senior leadership, (f) apply the key lessons of successful change management in higher education, (g) focus on the change-leadership capabilities identified in this study, (h) review EfS leadership position descriptions, selection processes and succession strategies in the light of the study’s findings, (i) apply the most productive approaches to leadership learning identified in the study to the professional development of EfS leaders’ (Scott et al, 2012: p.2).

Brinkhurst et al (2011) conducted a study to explore environmental sustainability and organizational transformation at universities across North American universities. Note Brinkhurst et al, these universities usually identify their sustainable development initiatives such as campus operations, financial and administrative planning, policy, curriculum and research that facilitate environmental changes, as either top-down (by university administrators) or bottom-up (by students), instead of focusing on the role of the ‘institution middle’ (p.340), namely the faculty and staff in the development of such initiatives. The top-down and bottom-up approaches have its own set of challenges, but also share similar setbacks. One similar challenge faced by both approaches is the creation of leadership gaps as a result of dependency on individual advocates who are substituted fast. The other similarity is the lack of awareness of the functioning of the university. This in turn leads to awareness raising type initiatives, rather than policy or planning changes. Top-down challenges include the lack of support from the university community and those involved with the governance of the university. The responsibility of representing a diverse set of stakeholders has also been cited as a challenge facing the top-down method. The complex nature of university governance and a perceived lack of institutional support are some of the barriers of the bottom-up approach. An adverse effect of the top-down and bottom-up approaches could be barriers to effective and long-term campus change. Given these challenges the engagement of the institution middle, i.e. the faculty and staff is seen as an important measure is achieving sustainability of the university (Brinkhurst et al: 2011). However, the institution middle approach does have its sets of challenges as well. These include resistance from uncooperative superiors or project partners, shortage of time, lack of authority, disempowerment as change agents within a bureaucratic institution, heavy workloads, job descriptions that do not clearly support sustainable development initiatives and apprehension of criticism from more authoritative or influential staff, faculty and groups (Brinkhurst et al: 2011).

In a study on the incorporation of sustainable development in university curricula, Lozano's (2010b) study of Cardiff University's adoption and diffusion of sustainability in its curricula indicated that there is a tendency for the university to address sustainable development as 'a 'portfolio' , where the schools rely on compartmentalization, over-specialization, and reductionism' (p. 643). This has resulted in the schools excelling in their individual areas and to a specific facet of sustainable development, instead of a holistic one. Lozano further notes that if sustainable development is integrated 'as a concept, in and among the different disciplines and schools, and tailored to their specific nature' (p. 643), universities could become more 'balanced, synergetic, trans-disciplinary and holistic' (p. 643) enabling its graduates to become more competent sustainability change agents. Lozano (2010b) also recommends sustainability reporting as a strategy for universities to gauge their environmental, economic, social and educational impact on sustainable development. Sustainability reporting is viewed as a useful strategy for universities to undertake in communicating sustainable development initiatives to stakeholders.

The Waas et al (2010) study focused on definitions and features of sustainable development research at universities. The study identified 22 preliminary sets of characteristics of university research from three sources of data, namely sustainability in higher education literature, sustainability in higher education documents and reports and workshop findings from the University of Antwerp in Belgium. The 22 characteristics identified were distinguished between content and process. It was also found that university research should also look into multidimensionality. Sixteen characteristics were suggested in relation to processes that university research for sustainable development must consider, among which include action-orientedness, management of the environment, safety and security, transfer of data through varying means and to varying groups, i.e. students, the general public and policy makers, multidisciplinarity, and interdisciplinarity to include the social sciences and the need for university research to be reviewed by the society.

Mickwitz and Melanen's (2009) study analysed the co-operation between Finnish academicians and local decision makers in the development of sustainability indicators. The main findings of their study were the importance of joint production of knowledge between academicians and stakeholders of Finland for the development of sustainability indicators. Their research further indicated that mere exchange of knowledge from the academia towards sustainability policy making strategies would defeat the rationale of the development of sustainability indicators for purposeful use.

A study conducted by Moore (2005) on recommendations that could assist universities in developing ESD programmes at the University of British Columbia found seven ways in which sustainable development could be infused within the broader context of the institution. These suggestions are therefore not curriculum or programme specific. The seven recommendations, obtained through a series of workshops and interviews with stakeholders were, (i) 'the infusion of sustainability in all decisions, through the incorporation of sustainable development in the university's vision and mission statements, goals and processes, (ii) the promotion and practice of collaboration across disciplines, (iii) institutional change for the promotion and practice of interdisciplinarity and transdisciplinarity, as a disciplined focus approach was seen to stifle creativity and innovative problem solving opportunities, and did not allow faculty members to teach outside their departments, given the structure of the university, (iv) creating a focus on personal and social sustainability through the reduction of work load, reconfiguration of timetables, added community involvement in teaching, and improved job security for sessional lecturers, i.e. contract based non-faculty lecturers with teaching responsibilities, (v) coordinating planning and assessment strategies with the university's academic plans, policies and implementation strategies, and using sustainable development indicators in evaluation criteria and performance indicators, (vi) integrating teaching , research and service, instead of overemphasising on peer-reviewed publication and research, and undermining the importance of teaching excellence, (vii) encouraging and supporting transformative and transdisciplinary undergraduate learning through student-centered learning, collaborative group work, increased interaction between students and lecturers, reflective and active learning' (Moore: 2005).

Apart from the studies highlighted above, there seems to be limited literature and research on strategies and barriers for the advancement of sustainable development within university policies and practices within non-Western contexts, particularly in Malaysia. The present study therefore aims to bridge this gap, through an exploration of the perspectives of academicians, university management and industry practitioners on the implementation of sustainable development within the Malaysian higher education context. The section that follows looks at research that has been conducted to understand higher education students' attitudes, feelings and views on the implementation of sustainable development within higher education.

2.2.3.2 Higher education students' reactions to the implementation of sustainable development

This section highlights studies undertaken to explore higher education students' views on sustainable development in higher education. As observed in the previous section on strategies and barriers, the research cited in this section have also mostly been conducted within western educational settings and circumstances, indicating that more research as such is needed within non-western educational perspectives.

Drayson et al (2012) conducted a national online survey to understand higher education students' attitudes towards sustainable development. The study also sought their views on skills needed to practice sustainability. Respondents of the study were 1552 first year students new to the university environment and 1641 second year students of British universities. All students who took part in the survey were enrolled for their first degree. The findings of the study revealed that 66.6% of first year students and 70.3% of second year students were of the opinion that sustainable development should be addressed in their universities. The 67.4% and 69% of first year and second year respondents also stated preference for sustainable development content to be reframed within the existing curriculum, instead of making it as an additional content or an additional module. Additionally, 32% to 46.8% of first year students were of the opinion that sustainability literacy skills were partially covered by the time they began university. It must be noted that the sustainability skills mentioned in the survey was not of a broad range of skills students would need. A total of nine items were included as skills for sustainability. These items covered issues such as ethics, problem solving and analysis, planning skills, understanding of nature and resources and being responsible citizens.

The findings of this survey also suggest that student' viewed these skills as important for their future employers. However, when students were asked to present their views on the importance of skills such as self-management, team work, business and customer awareness, problem solving, numeracy application, information technology application, communication and application of social and environmental skills for their future employers, it was found that students ranked the application of social and environmental skills relatively lower than the other skills. The study also found that as much as 74% of first and second year students were not convinced enough to change their first university choice based on the coverage of sustainable development at a university Drayson et al (2012).

The Sky Future Leaders (2011) study on the sustainable generation was undertaken to determine the attitudes of United Kingdom's future business leaders in relation to sustainable development. Respondents of the study were 751 graduate trainees, MBA students, fresh MBA graduates and middle managers identified for leadership positions. The study found that 34% of the respondents thought that the creation of social and environmental values was an important career aim. While 72% of the respondents were of the opinion that their present employers and higher learning institutions encouraged them to view issues using a long-term approach, surprisingly, only 35% of them feel that they have been provided adequate sustainable development training from their employers and higher learning institutions. In addition, 96% of the graduates indicated that they plan to be involved in sustainability in their careers. Similar findings on sustainability and career choice were found in the study conducted by Drayson et al (2012), where 63% of the respondents said they were willing to sacrifice £1000 from their salaries to work with employers who made sustainability a priority.

Lundholm (2006) conducted a study to explore students' learning experiences in environmental education in England and Sweden. Data was collected independently from secondary school students and university students on their experiences with environmental lessons. The findings revealed three important findings. Regardless of study levels, learning is fashioned by an emotional reaction to a feature of the issue learnt. The findings also showed that conflicts exist between students and teachers in relation to their beliefs or views on the environmental issues discussed. An issue deemed as important by the teacher, was not necessarily deemed as significant by the student. The last finding of her study was that school and university students felt that the content chosen by the teacher was inappropriate for inclusion within the curriculum. The students also indicated the need to include more cases and real examples that reflected the issues discussed. The findings also revealed that engineering students thought that the content was too focused on problems, and did not relate to their studies at the university.

Kelly's (2006) research investigated first year engineering students reactions on qualities of a *Globo sapien* and found that students regarded *Globo sapiens* as those who 'are sensitive to the different ways we learn from each other and know the world, show evidence of global consciousness, are able to contemplate changes to their current way of life, rather than taking its continuation for granted, capable of trans-generational thinking, are able to contribute to a learning society through growing dispositions of generosity, of openness and of serious engagement and are courageous' (p. 700-703).

Another study was conducted by Lundholm (2005) to explore undergraduate civil engineering, biology and postgraduate students' interpretation of environmental content. Three collective case studies were conducted through observation and interviews in two universities in Sweden for this purpose. The engineering and biology students' views were obtained based on their learning experience in ecology related modules, while postgraduate students' perspectives were gauged via their involvement in environmental research. The findings of the study indicate that students' views on environmentalism were driven by science, existentialism and politics. Additionally, the study also found that values and emotions played a role in the students' learning process.

In Malaysia, a national environmental study carried out by World Wildlife Fund (WWF) Malaysia (2008) found that university students had a 41.9% mean percentage on knowledge on the reasons for the occurrence of environmental problems. Surprisingly, university lecturers only had a 42.5% mean percentage of knowledge on environmental issues, while school teachers had the highest mean percentage of the three groups, with a mean percentage of 44.8%. Ironically, the findings indicate that university students had almost as much knowledge on the issue as their university lecturers did, while school teachers had the best understanding of environmental issues.

54.3% of university students indicated that their awareness towards environmental issues in their higher learning institution was developed through seminars and forums. Field site visits, activities on local environmental issues and an environmentally responsible culture at the university were also indications of the ways in which their universities developed their awareness on the environment, with 49%, 64.6% and 58.9% of the 416 respondents indicating so. Although the percentages are relatively low, this is an indication that

Malaysian universities are making some effort to promote awareness of environmental knowledge. Given these findings, more effort must thus be put in by universities in carrying of field visits and promoting an environmentally responsible culture at universities.

When university students were asked if field trips and environment related activities were important for them to develop knowledge on environmental issues, 92.8% of them agreed that such activities were important. Although 96.7% of university lecturers agreed that the provision of education on the environment was important, several barriers restricted their ability to infuse environmental content in the modules they taught. These included the lack of formal training (76%), not knowing how to implement activities (53.6%), no support from administrators (38.8%), environmental issues are not required to be tested in examinations (65%), busy students (73.8%) and lack of funds (34.4%). University students were also asked of their views on the best approach to learn about environmental issues. The findings indicate that only 5% of the respondents indicated that it should be infused through all modules within their programme of study.

The role of higher education in developing ESD has thus far been addressed. Discussions also revolved around the higher education community's commitment towards ESD. Strategies, barriers and reactions towards the implementation of sustainable development within higher education were also highlighted to enable a clearer understanding of the current progress in the implementation of sustainable development within the context of higher education. Given the limited amount of research conducted to understand engineering education stakeholders' perspectives on the incorporation of sustainable development within Malaysian undergraduate engineering context, there is therefore a need for this gap to be addressed. The studies highlighted also indicate that there is a lack of guidelines and frameworks for the implementation or assessment of EESD within the Malaysian higher education context. Additionally, issues of acceptance, internalization and implementation of sustainable development among undergraduate engineering education stakeholders such as academicians, university management, engineering industry practitioners and final year engineering students also remain vague. Sustainability, within the context of engineering education in Malaysia has been customarily introduced and dealt with within the parameters of engineering modules, and taught through the lens of technology. However, with current global trends towards interdisciplinary and the whole systems approach to sustainable development, the goals of imparting this knowledge within the conventions and confinements of the technical modules in Malaysian engineering education programmes may need to be revisited. Research on sustainable development ESD and EESD within non-engineering contexts or those involving non-engineering academicians who teach in engineering programmes also seems to be limited. Additionally, the extent to which Malaysian engineering and non-engineering academicians, students and even university management understand, identify, engage and even adopt academic practices and competences related to sustainable development and ESD within engineering programmes in their institutions of higher learning is another concern that warrants further discussion.

PART 2: SUSTAINABLE DEVELOPMENT AND THE MALAYSIAN UNDERGRADUATE ENGINEERING EDUCATION LANDSCAPE

2.3 Introduction

EESD, in the context of higher education, can only be realized when approached in a contextually meaningful manner. The issue of context is thus further deliberated in the next section, which focuses on sustainability and ESD from an engineering education context. This section discusses sustainable development within the local undergraduate engineering education landscape. Also highlighted are gaps to be looked into for the successful implementation of EESD in Malaysia.

2.3.1 Engineering Education within the Malaysian Higher Education Context

Prior to the discussion of engineering education in Malaysia, it is first necessary to understand the context in which these programmes are developed. This section therefore presents an overview of the higher education scenario in

Malaysia and positions engineering education within the Malaysian higher education set up.

Malaysia is fast growing as an international education hub. According to the Southeast Asian Ministers of Education Organization Regional Centre for Higher Education and Development (SEAMEO RIHED) report, as of August 2010, there were a total of 1050726 students in Malaysian higher education institutions, while the number of graduates stood at 250836 graduates. The number of faculty members stood at 55723. In the year 2011, the country was ranked at the 11th spot by UNESCO given its appeal to students from countries such as China, Indonesia, Middle East, North Africa and Western Asia. 2009 statistics from the Ministry of Higher Education (MOHE) indicate that the number of international students registered at the country's public and private institutions of higher learning has increased from around 2000 candidates in 1995 to 75000 candidates in 2009 (MOHE (c): 2013). As of August 2010, there were a total of 80750 international students from over 150 countries registered for higher education programmes in Malaysia.

The history of engineering education in Malaysia can be traced to 1956, and is projected to develop more rapidly in the years to come (MOHE (e): 2006). With the projected growth of engineering programmes in Malaysia, quality becomes an important element to address. This is to ensure that programmes offered at local institutions of higher learning are of a quality acceptable to professional engineering standards within the country and abroad. Accreditation is therefore the key to the assurance that these programmes are of adequate quality. As highlighted in the previous section, all higher education programmes in Malaysian are subjected to accreditation by the Malaysian Qualifications Agency. The accreditation of engineering programmes is conducted by the EAC, an entity instituted by the Board of Engineers (BEM), Malaysia, which is a government organization responsible for the regulation of the engineering profession and the registration of engineers in the country. The EAC's membership is made up of the Institution of Engineers Malaysia, the MQA, the Public Services Department of Malaysia, the Malaysian Council of Engineering

Deans and several industry practitioners and academicians appointed by the President of BEM.

In 2009, Malaysia, through the BEM, became a signatory member of the Washington Accord. The full membership awarded to Malaysia implies Malaysian undergraduate engineering programmes are at par with other signatory members of the Accord in terms of its accreditation criteria and systems (International Engineering Alliance: 2013). These include Australia, Chinese Taipei, Hong Kong China, Ireland, Japan, Korea, New Zealand, Russia, Singapore, South Africa, Turkey, United Kingdom and United States (International Engineering Alliance: 2013). An important outcome of membership in the Washington Accord is the implementation of the outcome based education (OBE) system and the move from prescriptive based education system (EAC: 2012). OBE is an educational system that focuses on the outcomes of the educational process to prepare engineering students for professional practice. In accordance with the principles of OBE, Malaysian undergraduate engineering education learning outcomes must be framed in relation to cognitive (thinking and knowledge), affective (feelings and attitudes) and psychomotor (doing and skills) domains. Learning outcomes must be specific, achievable, measurable, realistic, and observable. It must also be framed to include lower, intermediate and higher level of learning. The advantages of the OBE system include the nurturing of quality graduates, the implementation of more systematic educational processes and increased exposure to professional engineering practice through participation in activities linked to the engineering industry (MOHE (e): 2006). A major requirement of OBE is the documentation of evidence to demonstrate the students' achievements of the required outcomes. Continuous quality improvement (CQI) is another integral component of OBE. As a measure of continuous quality improvement, the views of stakeholders are engaged from the point of the conception of the design of the engineering programme curriculum and to the implementation of the said programme (MOHE (e): 2006).

In assuring the quality of undergraduate programmes, the EAC developed an accreditation manual to facilitate institutions of higher learning offering these programmes to meet the accreditation requirements of their existing and new programmes. The accreditation of undergraduate engineering programmes is bound by the following requirements: published programme objectives, a clear link between programme objectives, programme outcomes and course (module) outcomes, ongoing assessment that exhibit the accomplishment of programme objectives with documented results, assessment results that are used in the continual improvement of the programme and proof of stakeholder involvement (EAC, 2012). The programme outcomes students of undergraduate engineering programmes need to attain are: a) ‘Engineering Knowledge - Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialisation to the solution of complex engineering problems, b) Problem Analysis - Identify, formulate, research literature and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences, c) Design/Development of Solutions - Design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations, d) Investigation - Conduct investigation into complex problems using research based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions, e) Modern Tool Usage - Create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering activities, with an understanding of the limitations, f) The Engineer and Society - Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice, g) Environment and Sustainability - Understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development, h) Ethics - Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice, i) Communication - Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions, j) Individual and Team Work - Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings, k) Life Long Learning - Recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change, and l) Project Management and Finance - Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments' (EAC, 2012: p.2-3).

In positioning sustainable development within the professional context of undergraduate engineering education in Malaysia, it can thus be observed that the EAC Manual has not been developed with an EESD philosophy in mind. This conclusion was drawn based on the lack of evidence in the manual which suggests that sustainable development must be made a compulsory context within which all 12 undergraduate engineering programme outcomes must be developed. Interestingly though, programme outcomes c, f, g, h, i, j, k and l have direct references to knowledge, skills and values related to sustainability literacies. These outcomes make up 66.7% of the total number of outcomes. However, the suggested content for Malaysian undergraduate engineering programmes which comprises Engineering Sciences, Principles and Applications, Mathematics, Statistics and Computing, Engineering Applications, Complex Problem Solving, Complex Engineering Activities and Knowledge Profile draw little reference to sustainable development (EAC, 2012), indicating a mismatch. The section that follows looks at Malaysian undergraduate engineering education research and discusses its limitations in light of sustainable development.

2.3.1.1 Undergraduate engineering education in Malaysia: Bridging the sustainable development gap

A review on research conducted by Malaysian research universities indicates that undergraduate engineering education research in Malaysia has mainly centralized on (i) engineering graduates' employability skills and other skills relevant for the engineering workplace, (ii) pedagogies for engineering education and (iii) the Malaysian engineering education model. Although most research is not contextualized towards sustainable development or ESD, the importance for engineering graduates and students to be sustainability aware is evident. These three issues are discussed in the sub-sections that follow.

2.3.1.1.1 Research on skills for the engineering workplace

Mohd Nizam Ab Rahman et al. (2009) conducted a study on engineering students' perceptions of 17 attributes categorized as personal attitudes, communication and work attitude before and after industrial training. The 17 attributes include 'self-esteem, self and time management, self-confidence, punctuality, curiosity, presentable self-appearance, oral presentation skills, written communication, linguistic skills, discussion skills, ability to work independently, adaptable with environment, teamwork, ability to work under pressure, leadership skills, problem solving skills and subject knowledge' (p. 425). The findings of the study indicate that students' satisfactory levels of all three categories had increased after attending the internship programme, as opposed to prior to their participation. Of the 17 attributes listed in this study, it can be noted that teamwork, communication skills, problem solving and subject knowledge are closely related to sustainability education. However, the study does little to relate the importance of acquiring these attributes through internship for the development of the engineering graduates' sustainable engineering knowledge, values or skills.

In a similar study titled *Measuring the Outcomes from Industrial Training Programme*, Mohd Zaidi Omar et al. (2009) also explore the extent to which engineering students undergoing internship hold an understanding of environmental and global issues. This attribute scored the third lowest score of the 10 attributes explored, further indicating that more needs to be done to develop the engineering students' awareness of sustainability and sustainable engineering values, skills and knowledge for the workplace. With regards to employability and the engineering profession, Azami Zaharim et al. (2010) in their study of the employability skills of engineering graduates in Malaysia developed a framework called the Engineering Employability Skills

Framework. The framework developed provides a starting point for engineering students to develop and strengthen their employability skills before they enter the engineering workforce. Employability components within the framework include ‘communication skills, teamwork, lifelong learning, professionalism, problem solving and decision making skills, competent in application and practice, knowledge of science and engineering principles, knowledge of contemporary issues, engineering system approach and competent in specific engineering discipline’ (p. 924). Specific references are made to sustainability i.e. ‘the need for an engineering students’ understanding of environmental, social and cultural responsibilities and multidisciplinary engineering’ (p.924), but these are all represented in engineering contexts and disregard the role of non-engineering sustainability attributes such as values and appreciation for sustainable engineering.

2.3.1.1.2 Research on pedagogies for engineering education

Mohd Kamaruddin Abd Hamid et al. (2005) discuss the importance of developing appropriate case studies to address the learning outcomes of the course taught. In this study, an example of a case study is discussed to exemplify how it relates to problem based learning within a process control and dynamics context. The case featured in their study was developed using problem crafting features embodying real world experiences such as interdisciplinarity and collaborative learning. While these features of the problem crafting framework used in their study relate to important skills required for the engineering workplace, it was not explicitly developed to address sustainability issues. Jafni Mohd. Rohani et al. (2005) advocate the use of the Quality Function Deployment (QFD) tool to assess the effectiveness of problem based learning. The findings of their research suggest that while the tool was effective in bringing across problem based learning strategies there were exceptions such as the need for proper guidance on the identification of problems as well as the use of real cases from the industry. Their study also does not make references to contextualizing problem based learning within the context of sustainability education. In a 2009 study on profiles of professional engineers in Malaysia, it has been described that ‘theoretical and research orientation, application and practice orientation and a balanced orientation’ (a combination of theoretical and research orientation and application and practice orientation) are pertinent for engineering education in Malaysia (Azami Zaharim et al., 2009a: p.306-307). However, the findings of the study do not make explicit connections to how the profiles should be contextualized to sustainable development competences.

2.3.1.1.3 Research on the Malaysian engineering education model

There have been two studies conducted to attempt the development of a model for engineering education in Malaysia. The first is a study titled *A New Engineering Education Model for Malaysia* while the second is a study on an outcome based Malaysian engineering education model. The studies note five criteria and 6 skills and competences Malaysian engineering graduates need to possess to be able to exercise their engineering skills for the betterment of the society. The five criteria include 'scientific strength, professional competency, multi-skilling, well respected and potential industry leadership skills and moral and ethical soundness', while the six skills and competences highlight the need for Malaysian engineering graduates to have 'global and strategic skills, industrial skills, humanistic skills, practical skills, professional competency and scientific competency' (Megat Johari et al., 2002; Abang Abdullah et al., 2005). The importance for Malaysian engineering graduates to be aware of the impact of engineering practices on the society and within the global context is described in the five criteria.

2.3.1.1.4 Research on sustainable development in undergraduate engineering education programmes in Malaysia

Azmahani et al (2012) conducted a two phased mixed methods study on developing a structural model to assess first year undergraduate engineering students' knowledge and attitudes towards sustainability. In the first qualitative phase, interviews were carried out to identify the knowledge items for the development of the knowledge-attitude survey. The interview findings resulted in the development of two knowledge sub-scales, i.e. topics and basic knowledge of sustainable development (Azmahani et al, 2012). The attitude scale consisted of pro-self and pro-social sub-scales, which were adapted from the Environmental Assessment Inventory (Azmahani et al, 2012). The second stage of the study involved the administration of the survey to 188 first year students to determine the significance of the knowledge and attitude items. A total of 36 items made up the initial knowledge-attitude instrument. These items were reduced to 15 items after exploratory analysis, confirmatory analysis and structural equation modelling. The final items of the topics sub-scale were *climate change, environmental problems, global warming, ozone layer depletion* and *3R knowledge*. Items of the basic knowledge were *definition of sustainable development, three elements of sustainability* and *principles of sustainable development*. The attitudes items consisted of *I watch or listen to media programmes about sustainable issues, I take a short shower in order to conserve water, If I found water leaks, I would report it, I volunteer to work with local charities, I asked my parents to recycle some of the things we use, I asked others what we can do to help reduce pollution* and *I collect and sell recycle items such as papers, bottles and glasses* (Azmahani et al, 2012). In addition to the development of the instrument, the findings of the study indicated that basic knowledge on sustainable development has a strong correlation to develop student's attitudes, based on the results of the quantitative analysis of the study.

Sharipah Norbaini Syed Sheikh et al (2012) looked at newly enrolled first year undergraduate engineering students' perceptions on sustainable development in a public university in Malaysia. The study was conducted using interviews and observations. The findings of the study suggest that the first year undergraduate engineering students were oblivious to sustainable development. The findings of the study also indicate that the students were unable to explain what sustainable development was as they had not been exposed to it previously. The suggestion that students were ignorant of sustainable development, as indicated in this study, is rather discriminatory, as it suggests that Malaysian primary and secondary education does not develop sustainability awareness in its students. A study conducted by Tamby Subhan Mohd Meera et al (2010) is evidence of the inclusion of sustainable development content in Malaysian primary and secondary education, where the findings indicate that 35% of school students were knowledgeable of issues surrounding the environment. Although it can be argued that 35% is of a low percentage, it nevertheless indicates that Malaysian undergraduate students, who are products of the Malaysian primary and secondary education system, have been imparted with sustainable development knowledge. The argument, however, is the extent to which this knowledge has been effectively instilled.

Arsat et al (2011) conducted a study in which a review of 30 research articles was conducted to determine common models, approaches and orientations used by engineering programmes to develop courses on sustainability for engineering education. The findings of their study indicate that stand-alone and integrated models were most commonly used. In terms of orientation, the findings of the study indicate discipline specific sustainability courses as well as interdisciplinary courses as the type of orientation preferred for the development of such courses. Approaches most widely used were either singular (emphasis is placed on either the environmental, social or economic aspects of sustainable development), dialectic (a combination of two aspects of sustainable development, i.e. environmental and social, or social and economic) or consensual (environmental, social and economic aspects are equally balanced). The study also found the singular approach as the preferred course development approach used in Malaysian universities. Sumiani Yusoff (2005) conducted a study to identify a suitable approach to integrate sustainable development in the engineering curriculum. Findings of her study indicate that a value based engineering curriculum is essential for the development of sustainability in engineering programmes in Malaysia. The study also highlighted the need to review engineering education for achieving sustainable development, using this approach.

In Chapter 1, I discussed the need to re-position the present outcome based Malaysian undergraduate engineering programme curriculum within an ESD lens, using a holistic and whole institution approach, imbued within transformative education principles. The research cited in this chapter bear evidence of the limited emphasis placed on the integration of interdisciplinary, multidisciplinary and transdisciplinary sustainable development content in undergraduate engineering programmes in Malaysia. While research on sustainable development in undergraduate engineering exists, it has nevertheless been confined to studies on first year students' perceptions of sustainable development and assessments of their level of knowledge and attitudes towards sustainability. From a methodological perspective, most research on sustainable development within undergraduate engineering programmes in Malaysian universities has included quantitative and qualitative measures such as surveys, interviews and observations. However, responses elicited have tended to target a specific set of stakeholders of the educational institution, namely, first year students. There has not been much research conducted to obtain perspectives of stakeholders from multiple levels of the higher education system i.e. academicians, university management and members of the industry. Additionally, there is also a lack of importance placed on obtaining perspectives of ESD experts and practitioners. The present study has taken these limitations into account, and has included the perspectives of multilevel stakeholders, experts and practitioners to bridge this gap.

Given the lack of sustainable development integration guidelines provided to universities by the EAC and by their respective institutions, the development of an EESD framework that is drawn upon engineering, language, communication, business, social science and humanities perspectives, through a holistic and whole institution dimension is therefore necessary. A framework as such would address the current problems faced by universities and academicians on ways to integrate sustainable development outcomes within programme outcomes and module learning outcomes. Such a framework would also reduce the integration of outcomes that are too discipline centric, an approach deemed incongruent with the principles of sustainable development and ESD which advocate interdisciplinary, multidisciplinary and even transdisciplinary approaches. A vital aspect of this framework would be the types of competences the framework should be drawn upon. The section that follows discusses this further.

PART 3: SUSTAINABLE DEVELOPMENT COMPETENCES FOR THE ENGINEERING PROFESSION

2.4 Sustainable development competences

The Oxford dictionary defines the term *competence* as one's ability to do something successfully or efficiently. In the world of business, competence is seen as a set of associated abilities, commitments, knowledge and skills that enables individual or organizations to act efficiently in a profession or a situation. Competencies cannot be taught, but can be acquired from learning (Barth et al, 2007). Rieckmann (2012) believes that competencies are acquired during action.

Many studies have been conducted to gauge the development of competences in higher education. Barth et al (2007) for instance, are of the view that a new culture of learning is necessary for the development of competences in higher education. This new culture is in reference to learning processes that promote competence development on the foundation of three orientations, i.e. competence-orientation, societal orientation and individual centring (Barth et al, 2007: p.419). These orientations are presented in Table 2.1. For learning to take place within a competency based context, Barth et al (2007) recommend that it should be interdisciplinary, self-directed, experiential and tacit, whereby everyday life values, skills, attitudes and behaviours are unconsciously internalised.

Table 2.1: Learning for competence development

Competence orientation	Societal orientation	Individual centring
The focus of the learning processes is on attaining relevant key competencies. This requires a normative framework for the justified selection of such competencies in the same way as an educational concept is necessary which offers contents for developing competencies and helps to identify learning opportunities.	Learning takes place in real-life situations which question and change societal living.	Learning by the individual is seen to be active in the societal context. For formal learning processes this means a change from teacher to learner-centring. Additionally, informal learning processes should be taken into consideration for developing competencies, also and in particular at the university, because individuals not only learn in formal settings; informal settings also play an important role.

(Barth et al, 2010: p.419)

Research also indicates that higher education institutions have increasingly become an integral platform for the development of competences. The perspective on competences in higher education is supported by Rieckmann (2012), Fadeeva and Mochizuki (2010) and Barth et al (2007) who are of the view that universities should create teaching and learning situations that connect formal and informal learning which are interdisciplinary, transdisciplinary, participation and problem solving in nature, so that it would assist the development of competences that are fundamental to approaching sustainable and unsustainable development. While these efforts are elements of a sustainable university, Fadeeva and Mochizuki (2010) also assert that there still remain many debates surrounding the issue of competences in higher education, namely the issue of the choice and explanation of key sustainable development competences for higher education. In agreement with Fadeeva and Mochizuki (2010), Reickmann (2012) also believes that issues surrounding what these key competencies are and which are of significance, are yet to be addressed.

Reickmann (2012) further contends that sustainable development should be seen as a starting point for the selection of these key competencies. The lack of an international agreement on key sustainable development competencies and its global relevance is also still widely debated, even though many approaches have been put forth for the development of key sustainable development competences. These approaches, state Rieckmann (2012) include sustainability literacies, by Parkin et al., 2004, sustainability skills by McKeown, 2002, Hopkins and McKeown, 2002 and Stibbe, 2009, shaping competence by de Hann, 2006, key competencies by Rychen and Salganik, 2003 and knowledge, skills, values for sustainability by UNESCO (2005).

According to Brundiers et al (2010), research on sustainable development competences has garnered a lot of interest over the past few years. In their paper that briefly summarizes competencies for sustainable development, Brundiers et al assert that competencies can be grouped into three clusters, namely strategic knowledge cluster, practical knowledge cluster and the collaborative cluster. Citing de Hann (2006), Grunwald (2007) and Wiek (2007), they state that the strategic cluster ‘integrates systemic, anticipatory, normative and action-oriented competencies’ (p. 312). Competences within this cluster include

‘ analysing and understanding the status quo, i.e. current development, and past developments, i.e. history, creating future scenarios and sustainability visions, assessing current, past and future states against value-laden principles of sustainability and developing strategies to move from the current state towards a sustainable future’ (Brundiers et al, 2010: p. 310). An important competence in the first cluster is the ability to deal with diverse ‘opinion, perspective, fact, preference and strategy’ (Brundiers et al, 2010: p. 310). Citing van Kerkhoff and Lebel (2006), Brundiers et al note that the second cluster, the practical knowledge cluster comprises competencies which are vital for the bridging of knowledge and action related to sustainable development. An important competence of this cluster is implementation skills, a crucial factor of the *Gestaltungskompetenz*, which promotes hands-on experience to put knowledge into practice (Brundiers et al, 2010: p. 310). The third cluster, the collaborative cluster, is in reference to the competencies necessary for team efforts and to work in various knowledge communities. These are in tandem with recommendations provided by de Hann (2006) and Barth et al (2007). Competences grouped in this cluster include the ability to ‘engage with stakeholders, establishing consistent vocabularies, facilitating participatory research and decision making in collaboration with experts from academia, industry, government and civil society’ (Brundiers et al, 2010: p. 310).

In another study, Jucker (2011) highlights the essential knowledge, skills and values strands for a holistic approach to sustainable development, which he says ESD does not emphasise upon greatly. Many competences from the knowledge, skills and values strands recommended by Jucker (2011) bear resemblance to those mentioned by ESD researchers such as Sterling, 1998; Bowers, 2000, 2001, 2008, 2009; UNESCO, 2002; Jucker, 2002; Oreskes, 2004; Huckle, 2006; Selby, 2007 and Stibbe, 2009. While Jucker’s (2011) list of competences seems exhaustive, he acknowledges that a universal sustainability list for ESD is rather impossible to develop. Sharing Jucker’s sentiments on the impossibilities of a universal sustainable development competences list, Fadeeva and Mochizuki (2010), further argue that the European theorization of competence which has been globally influencing ESD discourse and practice, i.e. action competence, a Danish concept of competence, and the German concept

Gestaltungskompetenz, or shaping competence, could be another possible factor that hinders the development of a universal list.

The arguments put forth by Jucker (2011) and Fadeeva and Mochizuki (2010) on the inability to develop a universal sustainability literacy list for ESD are certainly valid. A reason for this inability, it is felt, could be the various contexts and cultures in which ESD operates within. From a contextual perspective, it could be a challenging task to integrate a universal sustainability literacies list within the curriculum of an educational programme. This is due to the specific conditions under which an educational programme operates within. Given its differing philosophies, a social science based programme for instance may not operate in the same manner a science based programme does. Similarly, there also are possibilities of differing philosophies towards sustainability within a single educational programme. For instance, a civil engineering programme may view sustainable development from an environmental angle, while an electrical and electronics engineering programme may view sustainability from economical perspectives. The educational philosophies of higher education may also differ from those of primary and secondary education. From a cultural viewpoint, a universal sustainability literacy list may not adequately address the finer issues and norms associated with a particular learning culture. The western-eastern ideology towards education is an example of this, where Western learners are adept to being more critical and outspoken, in comparison to their Eastern counterparts. The development of a contextually or a culturally relevant sustainability literacy list is therefore an ideal way of addressing this issue.

The discussion on sustainable development competences is further highlighted in section that follows, which looks into the competences engineers need, to be able to contribute sustainably to their profession.

2.4.1 Sustainable development competences for the engineering profession

According to the United Nations Economic Commission for Europe (UNECE) (2011), sustainable development competence illustrates an individual's ability to contribute to sustainable living within professional and personal capacities. Sustainable engineering is not a recent phenomenon. Professional engineering bodies over the world have been advocating for its advancement from the 1990s. The World Engineering Partnership for Sustainable Development is one such organization that has been championing for an engineering vision that is befitting to the challenges of the 21st century (Byrne et al, 2010). In keeping up with the sustainable engineering demands of professional engineering bodies, the Engineering Council of United Kingdom, in their report *Guidance on Sustainability for the Engineering Profession* state that

> 'A purely environmental approach is insufficient, and increasingly engineers are required to take a wider perspective including goals such as poverty alleviation, social justice and local and global connections. The leadership and influencing role of engineers in achieving sustainability should not be under-estimated. Increasingly this will be as part of multi-disciplinary teams that include non-engineers, and through work that crosses national boundaries'.
>
> (ECUK, 2009)

Sustainable engineering, i.e. 'practices that promote environmental, social and economic sustainability through greater resource efficiency, reduced pollution and consideration of the wider social impacts of new technologies, processes and practices' (Dowling et al, 2010, p.333), within the context of sustainable development, ESD and EESD has a plethora of meanings, note Byrne et al (2010). One significant goal is to encourage and enable students to take part in sustainable development oriented engineering practice and activity, state Kastenhofer et al (2010). Kasternhofer et al are also of the opinion that professional practice and performance are vital aims to be address through engineering education, besides understanding, skills and attitudes. The following quote elucidates this point further.

> 'It needs to make provision for the role of the engineer as an active player within society, or, in other words, as a social, political, and ethical persona. To achieve this, education has to provide opportunities to learn and reflect upon one's actions, the beliefs underpinning them, and their outcomes, in the context of professional agency. EE (engineering education) needs to address the way in which achieved competencies are applied in socially, culturally, and politically determined situations, including critical thinking and trying out different perspectives Otherwise, learned competencies remain merely theoretical abilities, while their actual application in real-world contexts is not considered'.
>
> (Kasternhofer et al, 2010: p.47)

As depicted in the quote, an engineer is seen as a social, political and ethical individual, negotiating his or her actions and beliefs within a professional platform. It is therefore necessary that the context of EESD is developed within multidisciplinary, interdisciplinary and transdisciplinary contexts of learning, as espoused by Barth et al (2007). The idea of transdisciplinarity within engineering education is further supported by Fokkema et al (2005), who state that a transdisciplinary sustainable development approach to engineering education would enable engineers to unreservedly communicate with engineers of other disciplines, as well as stakeholders of the engineering industry. This idea of flexibility is also supported by Hanning et al (2012), who believe that flexibility is crucial to the development of sustainable development competences.

Abdul-Wahab et al (2003) are of the opinion that environmental competences play a pivotal role in the development of sustainable development competences. This is due to the reason that engineers are bound to encounter environmental challenges during their careers. Abdul-Wahab et al also stress that engineering students need to be more environmentally conscious, 'so they can understand the importance of sustainable development and environmental protection, have a basic understanding of some of the environmental issues currently attracting public concern and to provide the scientific background and improve and reinforce knowledge about the environment as they approach the world of work (p.129). As engineers play a critical role in protecting the environment, Abdul-Wahab et al (2003) believe they should 'possess the scientific and technical knowledge to identify, design, build and operate systems that allow development while protecting the environment (p. 129).

Byrne et al (2010) further contend that despite the growing discussions on the incorporation of sustainable development in engineering education, there remains a lack of documented definitions for EESD, with the World Federation of Engineering Organisation's (WFEO) definition 'education that encourages engineers to play an important role in planning and building projects that preserve natural resources, are cost-efficient and support human and natural environments' (Byrne et al, 2010: p.3) being one of these definitions. There is also a lack of literature on competencies, graduate traits or learning outcomes related to EESD, assert Byrne et al. This is rather surprising, given the increasing emphasis placed on sustainable engineering and sustainable development outcomes within accreditation criteria of engineering programmes, as described in the Byrne et al study.

The issues projected by the researchers are evidence of the evolving demands for an increase in sustainability competent engineering graduates. These demands have received further attention from professional engineering bodies which increasingly call for engineering graduates to be sustainability competent. According to Byrne et al (2010), EESD has been receiving substantial international attention over the past ten years. Their observation was made based on recent key research within this area. The research cited in this study indicate the level of significance placed by engineering institutions in developing graduates who are equipped with the competences to deal with sustainability. It is interesting to note most the surveys were conducted to gauge the extent to which sustainable development had been incorporated within the engineering curriculum. Some of the surveys also looked into students' perspectives of their understanding of sustainable development, and that of their lecturers. Based on the findings of the EESD key surveys, it can be concluded that there is a lack of research being conducted to investigate the types of competences that should be incorporated within an EESD curriculum. Additionally, there also seems to be little research on interdisciplinary, multidisciplinary and transdisciplinary competences that should be included within an EESD undergraduate curriculum. There also seems to be a lack of research being conducted to understand non-western engineering education stakeholders' perspectives on EESD. These limitations are also relevant to the EESD scenario in Malaysia, where 66.7% of the Malaysian Engineering Accreditation Council's (EAC) engineering programme accreditation criteria are related to sustainable development competences.

In order to be able to incorporate sustainable development competences within the curriculum, there is an important need for engineering educators in Malaysia to be exposed to the competences related to ESD. The section that follows discusses these competences and highlights some of the pedagogies for ESD that are presently being used.

PART 4: PEDAGOGIES FOR ENGINEERING EDUCATION FOR SUSTAINABLE DEVELOPMENT (EESD)

2.5 Pedagogies for sustainable development and its implications for EESD in Malaysia

Education is a significant resource. Nevertheless, it could also be destructive, notes Schumacher (1973). For higher education, the necessity to concentrate on the sustainable development agenda through the curriculum is claimed to be the most imperative contribution that a university can make. Unfortunately, it is deemed to be the least developed (Martin & Jucker, 2005). Notes Sterling (2001), education as a whole must become ‘sustainable education’ if sustainability is to be introduced into the curriculum. Asserts Sterling (2004),

> ‘Sustainability does not simply require an 'add-on' to existing structures and curricula, but implies a change of fundamental epistemology in our culture and hence also in our educational thinking and practice. Seen in this light, sustainability is not just another issue to be added to an overcrowded curriculum, but a gateway to a different view of curriculum, of pedagogy, of organisational change, of policy and particularly of ethos’.
>
> (p. 50)

Although the call for educational reform had been sent out as early as the 1970s, at present, most education is seen to add to unsustainability, and does not do much to address the ‘whole person’ – spirit, heart, head and hands’ (Sterling, 2001: p. 12). He goes on to note that educational reorientations done have given education a very mechanistic paradigm, in which it is (a) ‘still informed by a fundamentally mechanistic view of the world, and hence of learning, (b) largely ignorant of the sustainability issues that will increasingly affect all aspects of people’s lives as the century progresses and (c) blind to the rise of ecological thinking which seeks to foster a more integrative awareness of the needs of people and the environment’ (Sterling, 2001: p. 13).

Pedagogies related to sustainable development centre upon principles that are associated with sustainability and pay importance to learner's beliefs, interaction, engagement and active creation of knowledge, which are all fundamental sustainable development learning principles. Thus, if the present needs of the people are to be addressed through engineering education, Sterling's (2001) notion of 'sustainable education' that puts forth a learning experience which is 'meaningful, engaging and participative, rather than functional, passive and prescriptive' (Sterling, 2001: p. 27) presents the much needed paradigm shift for an EESD curriculum that is holistic. A holistic engineering education curriculum will be a possibility only if sustainable development becomes an essential component of the university's engineering education curriculum, culture, policies and teaching and learning practices, as suggested by research on the implementation of sustainable development in higher education presented in this chapter.

Research on ESD reviewed over the past ten year period indicates that discussions have revolved around pedagogical notions such as experiential learning, deep learning, transformational learning, transdisciplinary and multidisciplinary learning, problem based learning, inquiry based learning, applied learning, active learning, participatory learning, critical emancipatory pedagogy and the use of environment and community as learning resources (Jucker, 2002; Reid, 2002; Wright, 2002; Calder and Clugston, 2003; Malhadas, 2003; Warburton, 2003; Welsh and Murray, 2003; Bartlett and Chase, 2004; Dale and Newman, 2005; Reid and Petocz, 2006; Kevany, 2007; Murray and Murray, 2007; Ellis and Weekes, 2008; Everett, 2008; Rode and Michelsen, 2008; Sipos et al 2008; Sherren, 2008; Svanström et al, 2008; Cotton and Winters, 2010). Approaches to learning include participative inquiry, transformative learning and action competence (Tilbury, 2007; Sipos et al, 2008; Breiting and Mogensen, 1999), while common teaching strategies encompass 'role-play and simulations, group discussions, stimulus activities, debates, critical incidents, case studies, reflexive accounts, personal development planning, critical reading and writing, problem-based learning, fieldwork and modelling good practice' (Cotton and Winter, 2010: p. 46-47). Futures thinking, envisioning, situated learning, multiple perspectives, effective communication training, action-oriented learning, engagement with real world issues and the whole systems approach are other common approaches recommended for ESD to be implemented effectively (Sterling, 1998, Jucker, 2011; Tilbury et al, 2005; Huckle, 2006; Künzli David et al, 2008; Shallcross, 2008; Jucker, 2011). Cotton and Winter's (2010) study indicates that pedagogies related to sustainability, had an initial focus on environmental education, and can be categorized into three classes. Table 2.2 provides further explanation of these three categories. As seen in the table, the three categories differ in its focus. The first category, education about the environment, promotes innovation and analytical notions of learning. Education in the environment on the other hand advocates the use of the environment as a real world educational source. The final category, education for the environment is focused upon the values, attitudes and behaviours in support of the environment.

Table 2.2: Environmental education about, in and for the environment

Education about the environment	Education in the environment	Education for the environment
Focuses on declarative knowledge and provides learners with information about environmental systems and issues using approaches designed to investigate and discover	Capitalizes on the environment as a real world resource for enquiry and discovery that can enhance the learning the learning process and challenge traditional understandings of metacognition	Conceptualizes the transformative and contentious component of environmental education, and requires the development of a personal environmental ethic, the values and attitudes that motivate behavioural change in favour of the environment

(Palmer and Neal, 1994, p. 19 in Cotton and Winter in Jones, Selby and Sterling, 2010, p. 41)

Sustainable development pedagogies have been applied in studies related to pedagogies for EESD. These studies have mostly focused on sustainable development pedagogical approaches that engineering educators could employ to integrate sustainable development within teaching and learning activities. One such study is *Educating for sustainability: opportunities in undergraduate engineering.* In this study, Crofton (2000) suggests that sustainability issues can be incorporated into engineering courses via the following means, i) 'Focusing on issues, problems, and/or solutions related to sustainable development in which engineers may be involved or may be expected to contribute, and highlighting the ways that course content (knowledge or skills) is needed to understand and effectively respond to sustainable development ii) identifying, developing, and using cross-disciplinary problems, case studies, projects and simulations that both reveal sustainability issues and are likely to help develop interdisciplinary knowledge and skills iii) the use of cooperative learning and collaborative teaching approaches' (p. 404). In another study, Huntzinger et al (2007) advocate the use of student-centered, problem-based and deep learning to advance sustainability ideas in undergraduate engineering students. Segalàs, Ferrer-Balas and Mulder (2010), in their research on the result of pedagogical approaches in sustainability courses, note that lectures, case studies, project and problem-based learning and role-play can develop understanding of sustainability. These findings bear resemblance to Crofton's (2000) findings. Segalàs, Ferrer-Balas and Mulder's study also revealed that while engineering education emphasized the need for engineering graduates to be well versed with the effects of sustainability to people, engineering students' comprehended technological solutions to sustainability better, in comparison to social and institutional aspects of sustainability.

This section provided a brief outlook of current research related to ESD pedagogies. The section also presented some of the recent research on sustainable development pedagogies in engineering education. Section 2.5.1 discusses the issue of ESD educator competences in light of EESD.

2.5.1 Sustainable Development and the Educator

Given the important role of educators in realizing a higher education institution's sustainable development goals, an understanding of the sustainable development educator is therefore essential. This section discusses some of the issues related to the sustainable development educator in relation to engineering education. It highlights research pertaining to the roles of these educators, the challenges they face and the relevant pedagogical support mechanisms that have been developed to assist these educators to play more effective roles as ESD educators. The section concludes by drawing upon current limitations within the present Malaysian EESD higher education classroom, and the need for appropriate educator competence guidelines to enable Malaysian EESD educators to effectively deliver sustainable development learning outcomes in higher education institutions.

2.5.1.1 The problematic of teaching sustainable development

Successful implementation of sustainable development in higher education is dependent on many factors, as presented in earlier sections of this chapter. Apart from the curriculum, the teaching and learning process and institutional policies and practices, the teaching staff play a significant role in driving the sustainable development agenda within the higher learning institution. The implementation of ESD would not be possible without the commitment of educators, comments Armstrong (2011). Armstrong's views are justified, as proven by the myriad of issues surrounding the implementation of ESD discussed in this chapter. A similar predicament faces EESD, as seen in the studies conducted by Mulder and Jensen (2006) and Bryce et al (2004). It was also highlighted that some of the reasons that hindered the integration of sustainable development were the educators' attitude, their lack of awareness and expertise on the subject matter and insufficient provision of training and support. Sterling (2011) contends that many educators find ESD exasperating, because they face difficulties in comprehending what it actually entails.

In 2005, a study was conducted by the UK based Higher Education Academy to investigate current practices and future developments on sustainable development in higher education. Researchers analysed 113 academic articles and monographs from key ESD resources to explore approaches used for the teaching of sustainable development within the higher education context. The findings of the study revealed that literature on the approaches to teaching could be grouped into three categories, namely the 'personal approach, connecting or re-connecting to reality and holistic thinking' (Dawe et al, 2005: p.10). The personal approach category consists of research that focuses on the role of educators in developing learners' understanding of sustainable development. Research within this category also emphasise on the advantages of educators and learners learning from each other. Personal convictions of educators, the teaching of ESD for life-long reinforcement, the development of student-centered curriculum, instilling a sense of ownership of the curriculum within learners and the need to define sustainable development related leaning outcomes were some of the major findings drawn out by Dawe et al (2005) from their study of the literature. The second category, connecting or re-connecting to reality, centres on experiential learning, interaction with the local community, focusing on real life issues and encounters, re-connecting people to other people and nature, developing ability among students to carry out societal transformation and making connections between sustainable development modules and the higher education institution's environmental management practices (Dawe et al, 2005). Key findings drawn by Dawe et al (2005) include the need to encourage and involve students to integrate university practices with personal choices, connecting with the local community living around the campus, training with industry partners and developing critical thinking to counter learning that was too inward-looking and reductionist in nature. The final category, holistic thinking, consists of research advancing the need to move away from reductionism, and to embrace critical thinking, systemic learning and interdisciplinarity, transdisciplinarity and cross-disciplinarity for effective teaching of sustainable development. Findings unique to research within this category were the importance of exposing learners to problem resolution, communication, values and involvement (Dawe et al, 2005).

Studies on the roles of sustainable development educators by Jucker, 2002, 2002a, 2004; Wals and Jickling, 2002; Welsh and Murray, 2003; Kevany, 2007 and Mulder, 2009, suggest that educators should be facilitators, should advance student-centered learning, should encourage the development of values in the process of learning, and must become learners themselves. These findings are similar to those described by Dawe et al (2005). In their study on current practices and future developments of sustainable development in higher education, Dawe et al (2005) state that educators should also be role models who share their way of life and sustainable development related experiences with students. Armstrong's (2011) research suggests the importance for educators to encourage ESD as learning, instead of forcing it upon learners.

The provision of means of understanding ESD competences, i.e. the educator's ability to assist people in developing sustainable development competence using innovative teaching and learning approaches (UNECE, 2011), is therefore necessary. Such opportunities would present educators with the support needed to comprehend what sustainable development entails, to enable them to carry out their pedagogical responsibilities in the most appropriate and effective manner. To date, there has not been much research conducted to identify the forms of competences needed for the teaching of sustainable development. The United Nations Economic Council for Europe (UNECE) ESD competences (UNECE, 2011) and the Future Fit framework (Sterling, 2011a) are two pedagogical guidelines that were recently developed to address issues surrounding educators' competences in integrating sustainable development content within teaching and learning. The section that follows discusses these frameworks further.

2.5.1.2 ESD competences for educators

The UNECE ESD competences for educators were developed in 2009 by an international working group, with a view of providing educators with a means to ease the integration of ESD in educational programmes. It additionally serves as a set of guiding principles for educators' competence development. The UNECE ESD competences is also said to serve policy makers as a tool to integrate ESD within formal education policies across all levels of education, in addition to being used for the purposes of curriculum development, professional development, the governance of institutions, assessment and monitoring (UNECE, 2011).

The UNECE ESD competences describe holistic approach, envisioning change and achieving transformation as essential characteristics of ESD. A 'holistic approach focuses on integrative thinking and practice. Envisioning change looks into alternative futures where one learns from the past and inspires engagement in the present. Achieving transformation highlights change in the way people learn and in the systems that support learning' (UNECE, 2011: p.6). Four approaches to learning are presented, namely, learning to know, do, live and learn to be. These learning approaches refers to the 'understanding of the challenges facing society both locally and globally and the potential role of educators and learners, developing practical skills and action competence in relation to ESD, contributing to the development of partnerships and an appreciation of interdependence, pluralism, mutual understanding and peace and addressing the development of one's personal attributes and ability to act with greater autonomy, judgement and personal responsibility in relation to sustainable development' respectively (UNECE, 2011: p.11). The UNECE educator competence guidelines and the Future Fit framework provide educators interested in embarking on sustainable development related teaching with a platform to engage with pedagogies relevant for the delivery of sustainable development content. Of both resources, the Future Fit framework is an instrumental tool which can be implemented by educators with some or little knowledge of sustainable development and ESD. The guidelines provided by this framework are very practical and can easily be adapted by the EESD educator. The UNECE framework on the other hand seems to be more suited to those who have a fairly good understanding of the notion of sustainable development. Unlike the Future Fit framework which provides examples of carrying out ESD related activities at the institutional and individual levels, the UNECE guidelines are more open for interpretation, making it challenging for novice ESD educator to adapt or adopt. Given the escalating interest in sustainable development and ESD in non-western nations, it would be interesting to see the manner in which frameworks similar to UNECE and Future Fit could be developed and implemented within educational contexts which are global as well as local in nature. Given the lack of such guidelines or frameworks for academic programmes in these nations, and specifically in Malaysia, there is an important need for more research to be conducted within this area. Guidelines on competences specific for EESD educators would also be necessary to address the lack of such support resources for these educators. These guidelines or frameworks should take into account educational theories, curriculum development approaches and instructional strategies to make it highly relevant to the needs of educators. Section 2.5.2 thus focuses on this aspect, further through a discussion of theories of learning associated with ESD and EESD.

2.5.2 Theories of learning, curriculum development and instructional strategies for EESD

Literature on pedagogies related to ESD and EESD within the higher education context have mostly highlighted the processes and strategies related to teaching and learning. Section 2.5 of this chapter provides examples of these. In 2011, the United Nations produced the United Nations Decade of ESD (DESD) monitoring and evaluation report on currently accepted learning processes aligned with ESD. These processes, which were collaboration and dialogue, engaging the whole system, innovation through transformative practice and active and participatory learning (Tilbury, 2011) were also discussed from the perspective of processes and strategies of teaching and learning.

The studies cited, as well as the 2011 DESD report findings point to a lack of discussion on the theories of learning informing ESD and EESD. Such discussions are important as it would enable engineering educators obtain an in-depth understanding of the pedagogical nuances at play within the EESD teaching and learning environment. This section therefore discusses relevant learning theories, curriculum development approaches and instructional strategies for EESD.

2.5.2.1 Transformative learning as a pedagogical orientation for EESD

In this chapter, it was noted that notions of learning such as experiential learning, deep learning, transformational learning, transdisciplinary and multidisciplinary learning, problem based learning, inquiry based learning, applied learning, active learning, participatory learning, critical emancipatory pedagogy and the use of environment and community as learning resources have informed much of the research on pedagogies for ESD. Many of these notions of learning have also informed research on EESD. Cooperative learning, student-centered learning, deep learning and problem-based learning are some of the instances of these pedagogical notions apparent in EESD, as evident in the studies highlighted.

The pedagogical notions surrounding sustainable development are indicative of teaching and learning approaches associated with the theory of constructivism. The rationale behind this observation is the evident emphasis placed upon engagement and interaction between learners, as well as between learners and teachers, within a community of learning that promotes student centeredness, reflexivity and transformation. The need for educators to be facilitators and motivators of learning processes which advocate the need for learners to understand multiple perspectives, and be immersed in learning situated within the context in which it will be applied, is further evidence and indication of constructivism. Strongly linked to these philosophies of teaching and learning is the transformative pedagogy, an adult learning theory deeply rooted within constructivism.

The theoretical orientation of the present study is informed by transformative pedagogies. This is due to several reasons. Transformative pedagogical notions are strongly linked to constructivist orientations. These orientations are seen as dominant in pedagogies related to ESD. The close association between the goals of ESD and transformative education which advocate the importance of being critical and reflective is another significant reason for this choice. Transformative pedagogies are also seen as the more significant preference, given its focus on adult education and teaching and learning processes within the context of higher education. As the present study is set within the context of higher education, the transformative paradigm thus serves as a fitting platform to better understand the pedagogical issues that surface from the findings of the study. The sections that follow rationalize the association between transformative learning and pedagogies related to ESD in greater detail.

2.5.2.1.1 Understanding transformative learning

Transformative learning is a learning theory that was developed by Mezirow, an adult learning educationist, in 1978. Transformative learning is ‘the process by which we transform our taken-for granted frames of reference i.e. perspectives, habits of mind and mind-sets, to make them more inclusive, discriminating, open, emotionally capable of change and reflective so that they may generate beliefs and opinions that will prove more true or justified to guide action' (Mezirow, 2000: p. 7). Transformative learning has been described as 'uniquely adult, abstract, idealized, and grounded in the nature of human communication' (Taylor, 1998: p.5). Notes McEwen et al (2011), 'transformative learning is learning that takes the learner's knowledge and skills into a new domain, with a change or in cognitive and affective processes. It recognises that learning is not necessarily 'gradual, progressive or linear, but may have significant thresholds for change in understanding and emotional intelligence' (p.37). Learning from a transformational perspective is seen to manifest when learners are prompted to analytically assess their perception of the problem. In understanding transformative learning, Imel (1998) states the importance of considering the manner in which it can be cultivated within the learning context, the educator and the learner. Eyler and Giles (1999) state the importance of comprehending the mechanics of transformational learning as it takes place when learners struggle to resolve a dilemma where the customary conduct of doing and seeing do not work, and when learners are asked to examine the validity of what they assume they are familiar with.

In discussing the link between ESD and transformative learning, Tilbury et al (2004a) argue that the 'conceptual congruence' between ESD and transformative learning is an indication that the aims of both concepts do go hand in hand. This congruence is observed in terms of similar goals of reflection at critical and personal levels, the emphasis on change as well as the shift in values and behaviours (Tilbury et al, 2004). For Cranton (1994), similarities between ESD and transformative learning are primarily seen in developing critical thinking and participatory learning. The relationship between ESD and transformative learning has also been discussed by Svanstrom et al (2008). Their research on the ESD goals of organizations at the regional and international level reveals that the ESD learning outcomes described by these organizations are transformative in nature. Echoing the views of Wals & Corcoran (2006), the Svanstrom et al study found that 'In order to achieve transformational learning you must critically reflect on your knowledge and experiences, continually question your assumptions, beliefs, values and act accordingly in your personal life, professional life and community life' (Svanstrom et al, 2008: p.343).

From a theoretical perspective, McEwen et al (2011) notes that there have been many conceptual discussions surrounding transformative learning. These include, amongst others, the significance of the rational and affective skill domains, the utilitarian approach to transformative learning which advances the provision of transferable skills and attributes, in contrast to the Freirian approach which promotes transformative learning as a 'liberating conscientization of the learner' (p.37), and systems thinking as a tool in understanding transformative learning. Additionally, Sipos et al (2008), contend that explicit learning occurring in the affective domain is where ESD and transformative learning converge. Similar views have also noted by Shephard (2008) who states that the 'essence of ESD is the quest for affective outcomes, relating to values, attitudes and behaviours and involves the student emotionally' (p.88). Such responses to the emotional facets of learning can notably improve students' commitment to learning and evaluation and in due course, their learning achievements (Mortiboys, 2002).

Discussions on transformative learning and sustainable development have also highlighted the issue of a shift of consciousness. Sterling (2011) advances the notion of levels of knowing in discussing the issue of consciousness. These notions which are made up of six levels, namely metaphysics or cosmology, paradigms or worldviews, beliefs or values, norms or assumptions, ideas or theories and action, 'suggests that deeper perceptions and conceptions inform, influence and help manifest more immediate ideas and they, in turn, affect more everyday thoughts and actions' (Sterling, 2011: p.21). It additionally suggests that the 'influence of deeper assumptions may not be consciously recognized' (Sterling, 2011: p.21). Sterling further states that this six levels of knowing have an impact on the process of learning. Within this context, transformative learning is therefore seen as 'learning which touches our deeper levels of knowing and meaning, and, by so doing, then influences our more immediate and concrete levels of knowing, perception, and action', notes Sterling (2011: p. 22).

Within the context of education, transformative learning has been employed based upon a few key themes, namely 'critical self-awareness, perspective transformation, expansion of conscientiousness and individuation' (McEwen et al, 2011: p.35). The key tenet of the transformation learning theory is perspective transformation, which can be categorised into three dimensions (Clark, 1991). These dimensions are psychological, convictional and behavioural. While the psychological dimension relates to the alterations in understanding of one's self, the convictional and behavioural dimensions refer to the reconsideration of belief systems and lifestyle adjustments, respectively (Clark, 1991). Other notions of transformative learning are explained further in Table 2.3.

Table 2.3: Notions of transformative learning

Notion	Explanation
Critical self awareness	Transformative Learning Theory describes a learning process of 'becoming critically aware of one's own tacit assumptions and expectations and those of others and assessing their relevance for making an interpretation' (Mezirow, 2000, p.4).
Perspective transformation	The learner undergoes 'a conscious recognition of the difference between [the learner's] old viewpoint and the new one and makes a decision to appropriate the newer perspective as being of more value' (Mezirow,1978: p.105). 'Transformative learning occurs as we struggle to solve a problem where our usual ways of doing or seeing do not work, and we are called to question the validity of what we think we know or critically examine the very premises of our perception of the problem' (Eyler & Giles, 1999:p.133).
Expansion of conscientiousness	'Transformative learning is the expansion of consciousness through the transformation of basic worldview and specific capacities of the self (Elias, 1997:p.3).
Concept of individuation	'Individuation involves differentiating and becoming aware of the presence of the different selves operating within the psyche. This requires an imaginative engagement with the unconscious, a working dialogue between ego consciousness and the powerful contents of the unconscious. According to Boyd, a transformative education fosters the natural processes of individuation through imaginative engagement with these different dimensions of one's unconscious life. This engagement reflects an ongoing dialogue between ego consciousness and one's unconscious' (Dirkx: 2000).

(McEwen et al, 2011: p.35)

The section that follows discusses the transformative learning theory from the perspective of higher education. Discussions encompass present research within the area and limitations that need to be addressed within the context EESD in Malaysian undergraduate engineering programmes.

2.5.2.1.2 Transformative learning within the higher education context and its implications for undergraduate engineering programmes in Malaysia

Recent developments involving transformative learning and higher education research suggest that the theory has been used in the understanding of university learning environments. Sterling (2001) for instance argues that the mechanistic, prescriptive and transmissive educational paradigm currently practiced in higher education may not be well suited to address the challenges facing the 21st century. This is due to the fact that the challenges of the 21st century need to be resolved via transformative, whole systems educational paradigms which are constructive, and engage learners in forming meanings of their experiences. The transmissive vs. transformative debate is illustrated in Table 2.4 from the dimensions of policy and practice.

Table 2.4: Transmissive vs. transformative education

	TRANSMISSIVE	TRANSFORMATIVE
(Practice)	Instructive Instrumental Training Teaching Communication of 'message' Interested in behavioural change Information –'one size fits all' Control kept over centre First order change Product oriented 'Problem solving'-time bound Rigid Factual knowledge and skills	Constructive Instrumental/intrinsic Education Learning (iterative) Construction of meaning Interested in mutual transformation Local and/or appropriate knowledge important Local ownership First & second order change Process oriented 'Problem-reframing' & iterative change over time Responsive & dynamic Conceptual understanding & capacity building
(Policy)	Imposed Top-down Directed hierarchy Expert-led Pre-determined outcomes Externally inspected & evaluated Time-bound goals Language of deficit & managerialism	Participative Bottom-up (often) Democratic networks Everyone may be an expert Open-ended enquiry Internally evaluated through iterative process, plus external support On-going process Language of appreciation & cooperation

(Sterling, 2001: p. 38)

It has been argued that the transmissive paradigm is not congruent with the goals of ESD. This is apparent from its advocacy of teaching and learning practices that encourage teacher-centeredness and high-handed policies that discourage employee level participation in decision making processes. The elements presented within the transmissive paradigm further echoes Hicks' (2002) concern on the current importance placed on cognitive learning, which has been deemed as insufficient for transformative learning. The transmissive paradigm also presents a lack of attention to the need for learners to be able to be critical, and reflective, using higher order thinking skills, which are requirements essential for ESD. Therefore, if ESD is to be implemented within an institution's curriculum, policy and practices, it is pertinent for transformative characteristics to be adapted, given the importance it places on learner centeredness and decision making processes that encourage multiple perspectives and participation amongst all members of the organization. These measures are akin to the whole systems or whole institution approach, an integral approach for ESD.

The whole systems or whole institution approach to learning 'seeks to see connections, relationships and interdependencies to view the whole instead of the parts (recognizing that the whole is more than the sum of its parts), but also to understand that intervening in one part of the system can affect not only the other parts but the whole system' (UN Decade of ESD Monitoring & Evaluation Report, 2012: p.28). Sustainable development, within a whole institution approach should permeate within an institution's day-to-day operations, such as its use of energy, mobility of the campus community, within the curriculum, namely its course organization, projects and content, within its pedagogy, namely its methods of teaching and learning, within the community, i.e. through participation of parents, and stakeholders of the institution (UN Decade of ESD Monitoring & Evaluation Report, 2012). Although whole systems has been deemed as a challenge to implement within higher education institutions, Sterling (2004) nevertheless contends that the whole system approach is a means in which individuals and institutions can respond to sustainable development. Other responses include denial, the bolt on approach, where new courses and modules containing elements of sustainable development are added to the curriculum and the built in approach, where sustainable development content in integrated within existing study and programmes (UN Decade of ESD Monitoring & Evaluation Report, 2012). Although the whole systems approach has been regarded as a complex undertaking, it has nevertheless been one of the preferred choices of ESD proponents (UN Decade of ESD Monitoring & Evaluation Report, 2012).

The issues discussed in this section extend upon the discussion on pedagogies for sustainable development and its implication for engineering education in Section 2.5 of this chapter, where references were made to Sterling's (2001) notion of sustainable education and the need to move away from mechanistic educational directions to orientations which are transformative in nature. Thus, in positioning EESD within transformative orientations, it is also necessary to understand the ontologies and epistemologies that influence ESD, namely idealism and realism.

Sterling (2010) is of the view that the realism vs. idealism debate has been an important influence on the international discussion on ESD. Notes Sterling, the realist orientation is focused upon the environmental or sustainable development aspects of ESD. The idealist orientation on the other hand pays attention to educational aspects. Realists therefore subscribe to the notion of 'education about and for the environment' while idealists look at it as 'education for being' (Sterling: 2010, p.52). Realist orientations are ontologically realist, and epistemologically objectivist and positivist. It is behaviourist in its understanding of learning, seeks behavioural change and pedagogically transmissive and instructive. Idealist orientations on the other hand are ontologically idealist and epistemologically constructive and interpretivist. It is constructivist in its understanding of learning, seeks self-development and pedagogically constructivist (Sterling, 2010). Realist orientations, which are driven by a sense of urgency, have an instrumental view of education and seek rapid infusion of sustainability within the curriculum, while idealist orientations pay emphasis on the need for contextualized knowledge forms, multiple approaches to knowing an issue and real world, active and participatory learning. Realists are also more accommodatory in their response to education, while idealists are reformatory.

The third paradigm, i.e. the sustainable education paradigm, integrates realist and idealist orientations of ESD within a greater whole (Sterling, 2010), and is thus seen as a more fitting platform for the positioning of EESD in comparison to a purely idealist or realist notion. This is due to its ontologically realist/idealist position, its participatory epistemology, its systemic understanding of learning which seeks wholeness, as well as its focus on transformative pedagogy (Sterling, 2010). These characteristics are seen to be relevant to the philosophies of engineering education and EESD, therefore making it an ideal platform to base the holistic and whole institution undergraduate level EESD framework the present study aims to develop.

In grounding sustainable education, Sterling (2001) advocates the necessity for an educational ethos (educational paradigm), eidos (organization and management of learning environment) and praxis (learning and pedagogy) based on whole systems which the realist and idealist orientation have not truly addressed. Whole systems can be defined as a means of 'thinking and being' to shift past analytic, linear and reductionists mechanistic forms which are deemed prevailing. Whole systems thinking provides the means of making holistic thinking comprehensible, easily reached and practical (Sterling, 2001). The steering theory of whole systems is 'wholeness' relative to 'purpose, to description and to practice'. When it is applied to educational settings, it is harmonious with 'values, knowledge and skills' associated with transformative change (Sterling, 2001). The whole systems model provides a basis for understanding the shift from current mechanistic paradigms to transformative paradigms via three dimensions, namely the perceptual, conceptual and practical dimension.

The three contextual levels to which whole systems thinking can be applied are ethos (educational paradigm), eidos (organization and management of learning environment) and praxis (learning and pedagogy), notes Sterling (2001). The three contextual levels respond to the perceptual, conceptual and practical dimensions respectively. Core values make up elements of the first level, i.e. extension. Level 2, connection, is made up of elements such as curriculum, evaluation and assessment, management and community. The third level, integration, comprises of elements such as views of teaching and learning, view of learner, teaching and learning style and view of learning (Sterling, 2001).

Educational responses to sustainability range from education about sustainability to education as sustainability comprising of three learning stages, namely accommodation, reformation and transformation. These stages correspond to education about, for and as sustainability, respectively (Sterling, 2001).

The perspectives on transmissive and transformative learning, realist and idealists orientations, sustainable education and whole systems discussed in this section show the immense need for change in the way educational paradigms, organization and management of the learning environment and learning and pedagogy is viewed and understood in higher education in Malaysia. The educational value and potential for the adaptation of transformative based sustainable education orientations for Malaysian EESD is immense, but overlooked. The present study thus hopes to look into the ways in which this approach can benefit undergraduate engineering education in Malaysia.

2.5.2.1.3 Transformative learning in view of first, second and third order change

It was earlier highlighted that learner's learn at different levels of knowing and meaning. From a transformative learning viewpoint, learning is seen as a process which affects the learner's deeper levels of knowing and meaning, which in turn influences the learner's knowing, perception, and action (Sterling, 2011). The views on learning can further be argued from the perspective of learning and change, namely, the first order, second order and third order (Sterling, 2011).

Change of the first order refers to 'change within particular boundaries and without examining or changing the assumptions or values' (Sterling, 2011: p.22) in relation to what a learner does and thinks. First order learning has been associated with teaching that advocates the transfer of information that is led by content, and is transmissive in nature. This form also does little to challenge the learners' viewpoints and beliefs. From organizational and individual perspectives, first-order learning and change focuses on doing things better, and is efficiency and effectiveness centered (Sterling, 2011). A limitation of the first order from the learner's perspective is its lack of focus on questioning during the learning process. From the point of view of a learning organization, first order teaching and learning would be seen as a drawback for institutions that seek to recognize transformative learning as a significant approach within its teaching and learning practices (Sterling, 2011).

Second-order change on the other hand is in reference to a change in the way of thinking, or in what a learner does, resulting from an assessment of suppositions and values. This form of learning is subjective in nature, where ‘meaning is recognised and negotiated’ (Sterling, 2011: p.22) amongst those involved in the learning process. The second order learning experience is deemed as more challenging for the learner. This is due to the fact that it is of a higher level of learning than the first. In second order learning, learners, and the organizations in which learning takes place will have the opportunity to critically assess, reflect and alter the learner’s and organization’s beliefs, values and assumptions that take place at first level learning. This process of critical assessment and reflection is said to be more permanent and reflective of learning which is transformative. Various terminologies have been used to describe first and second order change, i.e. basic learning and learning about learning, learning and meta-learning and cognition and meta-cognition, where the former is in reference to the first order, while the latter is refers to the second order (Sterling, 2011).

The third order of learning is epistemic in nature as it involves a change of epistemology of knowing and thinking that frames learners’ perspectives. (Sterling, 2011). The third order provides learners with the experience of seeing their worldview rather than seeing with their worldview, which in turn enables the learner to embrace other view points and draw upon other perspectives and possibilities (Sterling, 2011). This level of learning is also consistent with the transformative notion (Sterling, 2011). Additionally, higher learning levels are also seen to affect levels of learning which are lower, through changes in the learner’s way of acting and thinking, says Sterling (2011). Epistemic learning for instance affects second and first order domains, while the second order has an impact on the first order, making it a nested structure (Sterling, 2011). The characteristics of the three levels are summarised in Table 2.5.

Table 2.5: First, second and third order learning and change

Orders of change/learning	Seeks/leads to	Labelled as
First order change (Cognition)	Effectiveness/ Efficiency	'Doing things better' (Conformative)
Second order change (Meta-cognition)	Examining and changing assumptions	'Doing better things' (Reformative)
Third order change (Epistemic learning)	Paradigm change	'Seeing things differently' (Transformative)

(Sterling, 2011: p.25)

The change of learning order from the lowest (first order) to highest (third order) results in learners being conformative, reformative and transformative. The change in learners' perceptions, i.e. from the cognitive to epistemic level, does have its limitations and advantages, explains Sterling (2011). These drawbacks are seen in terms of learner resistance, as it 'poses a significant challenge to existing beliefs and ideas, reconstruction of meaning, discomfort and difficulty, but also sometimes excitement'(Sterling, 2011: p.25) .

2.5.2.1.4 Transformative learning in practice

There has also been much discussion on the conceptual and theoretical foundations of transformative learning. However the same cannot be claimed for the practical aspects of transformative learning, given the lack of research within this theory of adult learning by educators, asserts Taylor (1998). Other transformative learning issues that have been understudied include the adoption, assimilation and application of transformative learning theory ideas into higher education practice, the necessary circumstances and methods for nurturing transformative learning, the responsibilities of teachers and learners in creating a learning environment which is supportive of critical reflection, the exploration of alternative points of view and the role of the rational and the affective in the transformative learning process (Taylor, 1998).

Cranton (1994) who explored the educator's susceptibility in carrying out transformative learning found that those who practiced transformative learning during their lessons encountered a certain degree of unpleasantness.

> ‘Most of us feel discomfort in giving up positions of power, for example, and we worry about the reactions of colleagues or program administrators to our unorthodox approach to teaching. To become a truly equal participant in the group process is to feel vulnerable as an educator. Perhaps the roles evolve best with confidence in what one is doing and experience in doing it well’. (p. 31)

In discussing qualities of an effective educator, Hicks (2002) contends that many of them ‘often only make things worse for students by teaching about global issues as this were solely a cognitive endeavour’ (p.108). Sterling (2011) further suggests that transformative learning will be facilitated when there is intention on the part of the educator or curriculum designer, which has been born of the educator’s or designer’s own learning, to generate systems through which they can support exploring epistemic change as a collaborative inquiry. Sterling (2010) nevertheless cautions that the act of learning must be at two levels, namely a level which involves the ‘meaning making’ of the educator and the level that focuses on the ‘meaning making’ of others, a phenomenon Roling (2000) labels as ‘double hermeneutics’ (p.52). Equally important is the ‘readiness of the learner, the quality of the learning environment and the higher education institutions’ overt and implicit ethos and connectivity’ (Sterling, 2010: p.27 -28).

Besides Sterling (2010), Hicks (2002) advocates the need for learning to awaken the mind, heart and soul, while Rogers (1994) emphasises the need for learning to cut across five dimensions, namely the cognitive, affective, existential, empowerment and action dimension. ‘The cognitive dimension, which is seen as the foremost teaching approach, involves the intellect, while the affective dimension involves intellectual knowing moving to a personal and connected knowing, that involves emotions. The existential dimension is where learners are confronted with probing their values, living habits and the challenge of reforming their sense of self. The ‘empowerment dimension, which if the existential predicament has been determined, involves a sense of accountability, commitment and direction, while the action dimension, which, if the questions raised by the first four dimensions have been determined, involves the development of informed choices at personal, social and political levels’ (Sterling, 2011: p.26).

Also in support of transformative perspectives within the higher education context are Wals and Corcoran (2006) who are of the opinion that the position of sustainability in the higher education curriculum is to develop innovation and systemic transformations that will allow for more transformative learning to take place. They believe that transformative learning must place emphasis on ‘learning for being, alongside learning for knowing and learning for doing’ (Wals and Corcoran, 2006). Wals and Corcoran also believe that transformative learning requires ‘permeability among disciplines, the university and the wider community, and between cultures, along with the competence to integrate, connect, confront, and reconcile multiple ways of looking at the world’ (p. 107). They further contend that higher learning institutions must look into multiple ways of looking at a more sustainable world through four ‘transformative shifts or movements’ (p.107) as follows, (a) ‘transdisciplinary shifts - looking at sustainability issues from a range of disciplinary angles but also in ways not confined by any discipline, (b) transcultural shifts - looking at sustainability issues from a range of cultural perspectives but also in ways not confined by any one culture in particular, (c) transgenerational shifts - looking at sustainability from different time perspectives – i.e. past, present and future and (d) transgeographical shifts - looking at sustainability issues from a range of spatial perspectives – i.e. local, regional and global’ (p.107).

Transformative pedagogies have also created much teaching interest amongst ESD researchers and practitioners, as evident in documented research on the area. The findings of some of these studies are discussed at this juncture. Moore (2005) for instance conducted a study to ascertain if higher education was ready to embrace transformative learning as a platform for the creation of awareness on sustainable development. Although collaborative, cooperative and problem based learning have all been associated with ESD, she argues that transformative learning is seen as the better suited pedagogy to address ESD. The findings of the study also indicated that ESD is best when approached from an ‘interdisciplinary, collaborative, experiential and transformative manner’ (p.78). Moore (2005) nevertheless cautions against some of the criticisms against the implementation of transformative learning i.e. it can make learners become uncomfortable, frustrated, embarrassed and feel awkward when they are introduced to new forms of learning. This is due to their contentment with content oriented learning approaches. Additionally, the general complexities surrounding a transformative based lesson, namely the issue of time and effort that needs to be allocated to prepare for such lessons, and educators who lack the expertise and ability to conduct transformative based lessons, can also be problematic to the transformative learning process. Cranton's (1994) study however reveals that educators find it important to stress upon transformative learning processes in the adult learning classroom. This is because the inclusion of critical perspectives and reflective thinking within lessons would enable learners to practice making judgements or decisions, which are seen as skills deemed essential for self-directed learning.

In addition to Moore (2005) and Cranton (1994), Sipos et al (2008) advance the integration of transdisciplinary study (head), practical skills sharing (hands) and development and translation of passion and values into behaviours (heart), known as the head, hands and heart approach to encourage ESD using transformative learning. Elliot (2011) on the other hand investigated the effectiveness of transformative learning within the context of ESD through two curricula and research based projects at the University of Brighton. The findings of the study indicate that the two projects, i.e. the community participation and development project, and the curriculum outcomes, and sustainable teaching assessment and learning project benefitted from the transformative learning approaches within the context of ESD. Positive outcomes were observed in learners' level of understanding, complex decision making and the questioning of values. Other benefits observed were increased levels of motivated learning through community based volunteering.

Sterling (2010) believes that for transformative learning to be a truly effective ESD pedagogy, the role and awareness of the educator is of utmost importance. He argues that educators must be capable of creating a learning system that encourages change at the epistemic level. Therefore, if transformative learning for ESD is to be implemented effectively, educators must therefore be able to encourage learning. The creation of educational systems that allocate additional learning periods for reflection and the provision of support for educators and learners are seen as additional means for transformative learning to thrive within higher education.

The issues discussed in this section indicate the potential of transformative learning as an adult learning pedagogy within higher education. However, its benefit as an approach to the teaching and learning of EESD has been largely unrecognised in Malaysia. The lack of research on transformative education within higher education in Malaysia, and engineering education in particular is an indication of this limitation. As discussed earlier, most research on engineering education and EESD in Malaysia have been focused upon outcome based education and problem based learning, which does not significantly emphasise on the learner's ability to be critical, reflective and reflexive. There has also been limited research conducted on interdisciplinary, multidisciplinary and transdisciplinary learning experiences of undergraduate engineering students within the context of EESD. As the Malaysian undergraduate engineering education programme outcomes criteria advances the need for Malaysian engineering graduates to be able to exercise these abilities within interdisciplinary, multidisciplinary and transdisciplinary contexts, a more suitable approach is necessary to complement the existing outcome based education approach to Malaysian engineering education. Transformative education has the potential to develop these abilities, as it has been proven to be the more suitable pedagogical approach to address EESD from a holistic and whole systems perspective.

Although the interest in ESD and transformative education is growing, there is nevertheless a small amount of documented research in this area (Kagawa et al. 2006). The present study thus aims to contribute to this shortcoming from a Malaysian higher education perspective. Sterling's philosophies on sustainable education have provided important theoretical basis and understanding of ESD for the present study. The section that follows will proceed with the discussion of curriculum development approaches for EESD.

2.5.2.2 Curriculum development approaches for engineering education for sustainable development

The issue of delivery comes to the fore when deciding to integrate sustainable development within the curriculum. According to Sammalisto and Lindhquist (2005), it is necessary for academicians to decide of sustainable development is to be delivered using existing structures, i.e. through courses, topics or modules or if a new structure would be necessary, i.e. through the introduction of a new programme, major or module. Christensen et al. (2007) and Tilbury et al. (2004) also advance the necessity to decide on the mode of integrating sustainability within the curriculum, i.e. as a stand-alone module or through integration in all modules. The amount of focus placed on sustainable development content is another issue that has been debated upon when deciding to integrate sustainable development within the curriculum. This can be established via a discipline-specific focus, which is narrower, or cross-disciplinary focus, which is broader (Lozana, 2006).

While Armstrong (2011) argues that there is a need for a mechanism to reframe discipline-based content within the philosophy of sustainable development, Sterling (2004) points out that the build in and bolt on act of integrating sustainable development content lacks an epistemological platform which is sustainability oriented. Citing Bowers (2001) on the conflict of sustainability with traditional courses, Armstrong (2011) further notes that 'when sustainability is integrated in a fragmented way rather than systemically, a dichotomy emerges, causing the learner to feel as though they are being pulled in two very different directions' (p.18). Appropriate curriculum development approaches and instructional strategies are therefore essential for sustainable development to be fittingly integrated within the curriculum.

It was earlier highlighted that pedagogical notions surrounding sustainable development are indicative of constructivism. In line with constructivism is the curriculum development and instructional approach of Tyler (1949) and Eisner (2002). Both approaches have been used by Armstrong and LeHew (2011) for a holistic transformation of a course on sustainable development within the apparel industry. Tyler's and Eisner's curriculum development and instructional approaches, which also inform the present study, are seen as apt approaches that can be adapted to inform the pedagogical discussions of the present study for several reasons. The Tyler rationale provides support for the development of learning outcomes, which the present study seeks to develop as part of its holistic and whole institution framework for EESD. The Eisner approach, which is complementary to the basic doctrine of ESD, provides a better understanding of the manner in which these learning outcomes could be designed so that it could be appropriately delivered within the undergraduate engineering programme classroom.

The Tyler Rationale is an outcomes based curriculum development approach (Tyler, 1949). It therefore is a well suited curriculum development approach for EESD, given the emphasis placed on outcomes based approaches to learning by the Malaysian undergraduate engineering education programme accredited by the Engineering Accreditation Council of Malaysia. The main focus of the Tyler Rationale is planning, which is applied onto four important stages of the curriculum, namely the determination of the educational purpose, the selection of the learning experience, the organisation of the learning experience and the evaluation of the delivery of learning outcomes (Tyler, 1949). These four stages of curriculum development are described in Table 2.6, and adapted to the discussion of the curriculum development approach for EESD, of which the present study is focused upon.

Table 2.6: Adaptation of the Tyler Rationale curriculum development goals to EESD curriculum development goals informing the present study

Tyler Rationale	Adaptation to EESD for present study
Determining the educational goal In this stage of the Tyler Rationale, learners and stakeholders needs and interests are determined through the collection of data which can be quantitative and qualitative in nature. Learning outcomes are then derived from the data and examined, so it is aligned with the desired educational philosophy and educational psychology.	**Determining the educational goal** Data collection from undergraduate engineering education stakeholders and ESD experts, analysis of programme and module outcomes and review of literature on sustainable development, ESD, EESD and transformative learning.
Selecting learning experiences Learning experiences are designed in relation to the learning outcomes derived from stage 1.	**Selecting learning experiences** Learning outcomes developed in accordance to the needs analysis from stage 1.

Organizing learning experiences The learning outcomes are positioned within the learner's learning experience using methods such as continuity, succession and integration. Specific lessons, topics and timing for implementation are then prepared.	**Organizing learning experiences** Positioning of the learning outcomes within specific lessons and topics and determination of timing for implementation of the outcomes are beyond the scope of the present study. However, the suitability of the learning outcomes for possible inclusion in selected modules are determined through appropriate data collection methods.
Planning for the learning outcomes delivery evaluation Evaluation methods used are guided by the learning outcomes.	**Planning for the learning outcomes delivery evaluation** Evaluation methods for the learning outcomes developed are beyond the scope of the present study. However, the use of appropriate evaluation methods is gauged through data collection with stakeholders.

Although Tyler's curriculum development approach has received wide spread approval by curriculum development theorists, there still exist criticism against this approach. Marsh and Willis (2007) state that Tyler's approach received criticism due to its systematic and outcomes based approach to curriculum development. Such approaches can sometimes be seen as setbacks to ESD which often subscribe to the development of learning experiences and assessment practices which are at times difficult to measure. However, Armstrong and LeHew (2011) are in support of this approach as it provides educators who do not have teaching qualifications or have little knowledge of developing curriculum with an essential scaffolding structure to develop a curriculum on their own. Tyler's curriculum development approach is also seen as an integral approach in the present study, due to its outcomes based emphasis. As undergraduate engineering education in Malaysia subscribes to the outcomes based approach, Tyler's curriculum development approach provides academicians teaching in engineering programmes the required input to develop effective and appropriate outcomes based educational outcomes.

While Tyler's approach to curriculum development will be able to provide educators with the opportunity to develop learning outcomes appropriate to the needs of the outcome based undergraduate engineering education curriculum, Eisner's approach to curriculum development, which is said to be more inclined to constructivism, will provide educators with the input needed to design learning experiences aligned to constructivist tenets of ESD. The adaption of an amalgamated version of Tyler's and Eisner's approaches to curriculum development is thus seen as the best way to approach the development of the EESD curriculum, where Tyler's approach would be instrumental in developing learning outcomes, while Eisner's would be essential in designing learning experiences that are responsive to the learner's context. Eisner's approach also emphasises the need for educators to allow room for emergent outcomes, and is thus important in assisting educators design learning outcomes that are broad enough to accommodate emergent outcomes from the learner's educational experience. Eisner (2002) outlines seven curriculum development approaches for educators to consider. These approaches can be utilised in any order and during any given time of the educational experience. These seven considerations are as outlined in Table 2.7. References are also made in the table as to the manner in which these considerations would be adapted for the purpose of the present study.

Table 2.7: Adaptation of Eisner's approach to curriculum design

Eisner's considerations	Adaptation to EESD for present study
Identification of learning goals Learning outcomes are enhanced to make it more expressive and less explicit and rigid. This provides room for emergent outcomes which could be expanded or changed. Learning outcomes should also include those driven by values and intent rather than focusing solely on measurable outcomes	Learning outcomes developed are of a combination of explicit and emergent outcomes, which are measurable and immeasurable.
Creation of content Content should address explicit, implicit and missing information	The creation of content is beyond the scope of the present study which focuses on the development of learning outcomes. However, measures were taken to ascertain information on explicit, implicit and missing content that could be included.
Development of learning opportunities Learning opportunities should be tailored to engage learner engagement instead of focusing solely on the subject matter	Discussion on learning opportunities in the present study includes issues pertaining to subject matter and learner engagement.
Organisation of learning opportunities Learning opportunities should engage learners in discovery based learning. Learning that provides learners with the opportunity to develop ideas and skills through engagement and action related activities. The educator assumes the role of a facilitator.	Discussions on the organization of learning opportunities in the present study addressed issues such as learner's critical thinking ability, reflective and reflexive thinking ability, experiential learning, situated learning, individual and group based learning, the educator's approach to teaching and the learner's approach to learning, amongst others.
Organization of content areas Content areas are organised using structures specific to disciplines of study and establishing strong links to content areas across the curriculum	Content area organization is beyond the scope of the study. However, discussions were conducted to ascertain potential of engaging discipline specific and non-discipline specific content across the curriculum.
Presentation of learning opportunities Presentation of learning opportunities to include verbal and written modes and should take into	Educator's mode of delivery and learner's communication of their learning have been included in the discussion.

account the learner's varied learning and communication styles. Attention must be paid to educator's mode of presentation and learner's communication of their learning.	
Development of assessment procedures The use of authentic assessment that promote better learner understanding and retention of learning, and is able to gauge the manner in which learners arrive at an outcome, rather than measuring the outcome. Assessment should be ongoing and not a separate process at the end of the learning process.	Discussion on assessment procedures have been included to better understand the assessment methods practiced.

2.6 Conclusion

This chapter began with a discussion of sustainability within the context of higher education. This was followed by information on the engineering education scenario in Malaysia, and the sustainable development competences required of an engineer. Also included in this chapter were issues surrounding the sustainable development educator as well as pedagogical and curriculum development approaches for sustainable development, namely transformative learning, the whole systems approach, the various orders of learning and knowing, and Tyler's and Eisner's curriculum development approaches. The issues discussed throughout Chapter 2 frame the theoretical orientation of the present study and inform the development of the research instruments. The issues highlighted in this chapter are also instrumental in further understanding the findings derived from data collected. Chapter 3 proceeds with the methodology used for the present study.

CHAPTER 3

METHODOLOGY

3.0 INTRODUCTION

This chapter focuses on the methodology of research used in the present study. Discussion will encompass the choice and justification for the research method used in the study, the design of the research, the approach to data collection and the research instruments used. The chapter will also highlight outcomes of the pilot study phase of the study and measures taken to improve the research instruments as a result of the pilot study phase. As the study adapted a case study approach, information on the research setting is also presented briefly. The chapter ends with a discussion of the ethical issues considered for the study.

Mixed methods research designs have become the research design of choice for many researchers engaged in evaluation, social and behavioural research over the last ten years. Mixed methods research has also been considered an important research design in educational research (Johnson and Onwuegbuzie, 2004). Prominent proponents of mixed methods research include Creswell (1994, 2003), Creswell and Plano Clark (2007), Tashakkori and Teddlie (1998, 2003) and Greene, Caracelli and Graham (1989). While authors like Tashakkori and Teddlie (1998) consider mixed methods as a research methodology with philosophical assumptions, other mixed methods proponents like Greene, Caracelli and Graham (1989), Creswell (2003) and Creswell and Plano Clark (2007) focus on the methods used for the collection and analysis of data.

3.1 Research paradigms

‘Worldview’ or ‘paradigm’ as it is also known refers to the manner in which we view the view the world. The way we view the world has an impact on the manner in which we conduct research. State Guba and Lincoln (2005), worldviews are made up of a set of beliefs and assumptions which in turn direct the investigation of the research. Notes Creswell (2003), there are four worldviews associated with research. These are postpositivism, constructivism, advocacy and participatory and pragmatism. Postpositivism and constructivism are worldviews associated with quantitative and qualitative approaches respectively. The advocacy and participatory worldview is usually associated with qualitative approaches rather than quantitative approaches, and are influenced by political concerns (Creswell and Plano Clark, 2007). Postpositivism is mostly associated with variable measurement, testing of theories and cause and effect. Constructivism, on the other hand is a result of subjective views of participants that are shaped by their individual and collective social interactions. Unlike postpositivism which tests theory, in constructivism, data leads to theory. Pragmatism is associated with research that is of a mixed methods nature, is focused upon the consequences of research, and employs multiple data collection methods to look into the issues the researcher seeks to study. Pragmatism is also focused towards practice (Creswell & Plano Clark, 2007).

Worldviews are incomplete without the elements they represent. All worldviews have five common elements. These elements are ontology, epistemology, axiology, methodology and rhetoric, and refer to ‘the nature of reality, the manner in which we get knowledge of who we are and the relationship that exists between the researcher and the entities being researched, the role values play in research, the process of research and the language of research’ respectively (Creswell & Plano Clark, 2007, p. 23). It must be noted here that all five elements are common to all four worldviews. However, the different worldviews have different stances towards these elements.

3.1.1 Pragmatism and mixed methods research

The discussion on ontology, epistemology, axiology, methodology and rhetoric in the present study will be focused within pragmatism, as the present study lies within this worldview. Pragmatism has been described as the philosophical dimension for mixed methods research (Johnson and Onwuegbuzie, 2004). Quoting Pierce (1878), Johnson and Onwuegbuzie note the following,

> ‘the pragmatic method or maxim (which is used to determine the meaning of words, concepts, statements, ideas, beliefs) implies that we should consider what effects that might conceivably have practical bearings, we conceive the object of our conception to have. Then our

> conception of these effects is the whole of our conception of the object' (2004: p.17)

The core tenets of pragmatism, state Johnson and Onwuegbuzie (2004), are the practical and empirical consequences of the research that is to be undertaken. They go on to reject the incompatibility approach to paradigm selection which advocates for a single approach to research (either quantitative or qualitative), and advocate a more 'pluralistic or compatibilist approach' (p.17). In pragmatism, ontology, which is the nature of reality, is represented either through single or multiple realities. Epistemologically, pragmatism is practical, where the researcher collects data to address the issue or issues under study using means that are most suitable. From an axiological perspective, the researcher takes on multiple stances and includes biased and unbiased viewpoints. Methodologically, pragmatism is about collecting quantitative and qualitative data and combining the data to address the issues under study. The quantitative and qualitative elements allow for deductive and inductive thinking to take place. While deductive or postpositivist thinking is closely related to quantitative data, inductive or constructivist thinking is related to qualitative data. From the perspective of rhetoric, the fifth element of worldview, pragmatism advocates formal as well as informal writing styles (Creswell and Plano Clark, 2007). Pragmatism, nevertheless, is not without shortcomings. Some of the weaknesses of pragmatism have come to include its promotion of 'incremental transformations rather than more fundamental, structural, or revolutionary changes' (Johnson and Onwuegbuzie, 2004: p.19). Another argument on pragmatism is its occasional shortcoming in being able to address the usefulness of pragmatic solutions. These inadequacies can nevertheless be addressed through the researcher's clear rationalization of its uses (Johnson and Onwuegbuzie, 2004).

In formally defining mixed methods research, Johnson and Onwuegbuzie (2004) are of the opinion that this form of research is of

> 'the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study. Philosophically, it is the "third wave" or third research movement, a movement that moves past

> the paradigm wars by offering a logical and practical alternative. Philosophically, mixed research makes use of the pragmatic method and system of philosophy. Its logic of inquiry includes the use of induction (or discovery of patterns), deduction (testing of theories and hypotheses), and abduction (uncovering and relying on the best of a set of explanations for understanding one's results)' (p.17)

Mixed methods research, state Johnson and Onwuegbuzie (2004) further, is an eclectic, unrestrained and innovative research form, which attempts to legitimize the use of multiple approaches to answer research questions. It has also been described as an 'inclusive, pluralistic, and complementary' (p.17) approach to thinking about and conducting research. A fundamental aspect of mixed methods research is its emphasis on the research question, i.e. 'research methods should follow research questions in a way that offers the best chance to obtain useful answers' (p.17).

The worldview or paradigm for my study is one that is based on pragmatism, for several reasons. Firstly, it allows me to use quantitative and qualitative research methods in a single study without having to participate in the postpositivist – constructive paradigm debate. The pragmatic worldview also allows me to employ deductive and inductive approaches for my study and combine the data to answer my research questions. Last but not least is its practically in collecting the data for my study, where I am able to collect both quantitative and qualitative data concurrently, within a single phase of study. My choice of using a mixed methods approach instead of employing a solely quantitative or qualitative approach for the present study is due to the fact that the combination of quantitative and qualitative data would present a more inclusive representation of my study. The use of quantitative and qualitative data sources would enable me to depict trends as well as in-depth perspectives of participants of my study.

My position on mixed methods is therefore two-fold. I view mixed methods as a research design with philosophical assumptions and one that is driven by quantitative and qualitative methods of inquiry. I have chosen this mixed methods stand for several reasons: (a) it provides me with the philosophical underpinnings that guide me in collecting, analysing and mixing the quantitative and qualitative approaches in the phases of my research, (b) it assists me in comprehending my research problem better, in comparison to using only a quantitative or qualitative inquiry approach, (c) it enables me to compare, validate and converge the quantitative and qualitative findings of the study, and (d) it allows multiple perspectives to enable better understanding of the research problem through pragmatic and practical means.

My understanding of mixed methods research is driven by the works of Creswell and Plano Clark (2007) and Johnson and Onwuegbuzie (2004) as I find that their stand on mixed methods is comprehensive, straightforward and in line with my own beliefs on mixed methods research. My choice of using a mixed methods approach is due to the fact that the combination of quantitative and qualitative data would present a more inclusive representation of my study. The use of quantitative and qualitative data sources would enable me to gather information from the larger population and depict trends using surveys, as well as gather in-depth perspectives of participants of my study using interviews. I have also chosen the mixed methods stand as it enables me to compare, validate and converge the quantitative and qualitative findings of the study and allows multiple perspectives to enable better understanding of the research problem.

3.1.2 The mixed methods case study

This research also adapted a case study approach. The research took place at a private university located in Perak, Malaysia. While there is a tendency for case study research to be qualitatively led, Bryman asserts that 'case studies are frequently the sites for the employment of both quantitative and qualitative research' (2001, p.48). The present case study thus employs both quantitative and qualitative measures as described by Bryman (2001) via a mixed methods triangulation design. The aim of this case study is not to account for generalizability, but rather to provide depth. Even so, the findings of the study could be used as guiding principles for Malaysian institutions of higher learning seeking ways to integrate or evaluate ESD learning outcomes or EESD within their respective engineering curriculum. My role as a researcher is thus to provide a balanced interpretation and analysis of the data obtained. The mixed methods approach was used for the collection of data for the present study, in line with Bryman's assertion of the use of quantitative and qualitative sources in case studies.

3.2 Triangulation and mixed methods research

This study employs a triangulation mixed methods research design, in which quantitative and qualitative approaches are used to collect different but complementary data to address the research aims of the study. The research aims are thus addressed using the following data collection procedures specified: (a) Survey administered to final year undergraduate engineering students, which aims to describe and explore final year undergraduate engineering students' views, (b) Interviews with engineering programme stakeholders, namely engineering and non-engineering lecturers, undergraduate engineering students, university management and engineers from the industry. Interviews with ESD practitioners and ESD experts were also conducted to obtain additional input for the study, (c) Document analysis of vision and mission statements of the higher learning institution, undergraduate engineering programme educational objectives, programme outcomes and common engineering and non-engineering module learning outcomes. The triangulation design, which aims to merge different methods, has been discussed at great length in research literature. Proponents of the triangulation design include Jick (1979), Brewer & Hunter (1989), Greene et al (1989), Morse (1991) and Creswell et al (2003). The triangulation design in the most frequently used mixed methods design in research. This design is also a well- recognized mixed methods approach (Creswell & Plano Clark, 2007). According to Morse (1991), the triangulation design is useful to 'obtain different but complementary data on the same topic' (p.122). The triangulation design is usually employed when the researcher wishes to collect and analyse 'concurrent but separate' quantitative and qualitative data (Creswell & Plano Clark, 2007, p.64). The aim of using the triangulation approach is to understand the research issue in the best possible manner. Upon data collection, the data sets are analysed separately. The results of both data sets are then merged either by combing the separate results in the interpretation or by transforming the qualitative or quantitative data to assist with the integration of the two types of data during the stage of analysis.

It must be noted here that the triangulation design is also referred to as the concurrent triangulation design (Creswell et al, 2003). Nevertheless, for the purpose of this study, the term convergence will be used when referring to this variant of the triangulation design. Variants of the triangulation design include the convergence model, the data transformation model, the quantitative data validation model and the multilevel model. In terms of triangulation design variants, this study combines two triangulation design variants. These variants are the convergence and multilevel mixed methods designs.

The present study is a quan+ QUAL single phase study, with the qualitative aspects given higher emphasis. The quan+QUAL single phase study enabled me to collect both quantitative and qualitative data for the study during the same time period. By using the quan+ QUAL single phase study, I was able to combine both quantitative and qualitative data to present a more comprehensive and rigorous study, as I was able to describe trends through the survey, and in-depth viewpoints of participants through interviews. The rationale for using the quan+QUAL triangulation mixed methods design in this study was to obtain different but complementary data on the same research issue. The single study phase ensured efficiency, given the time frame available for the collection of data.

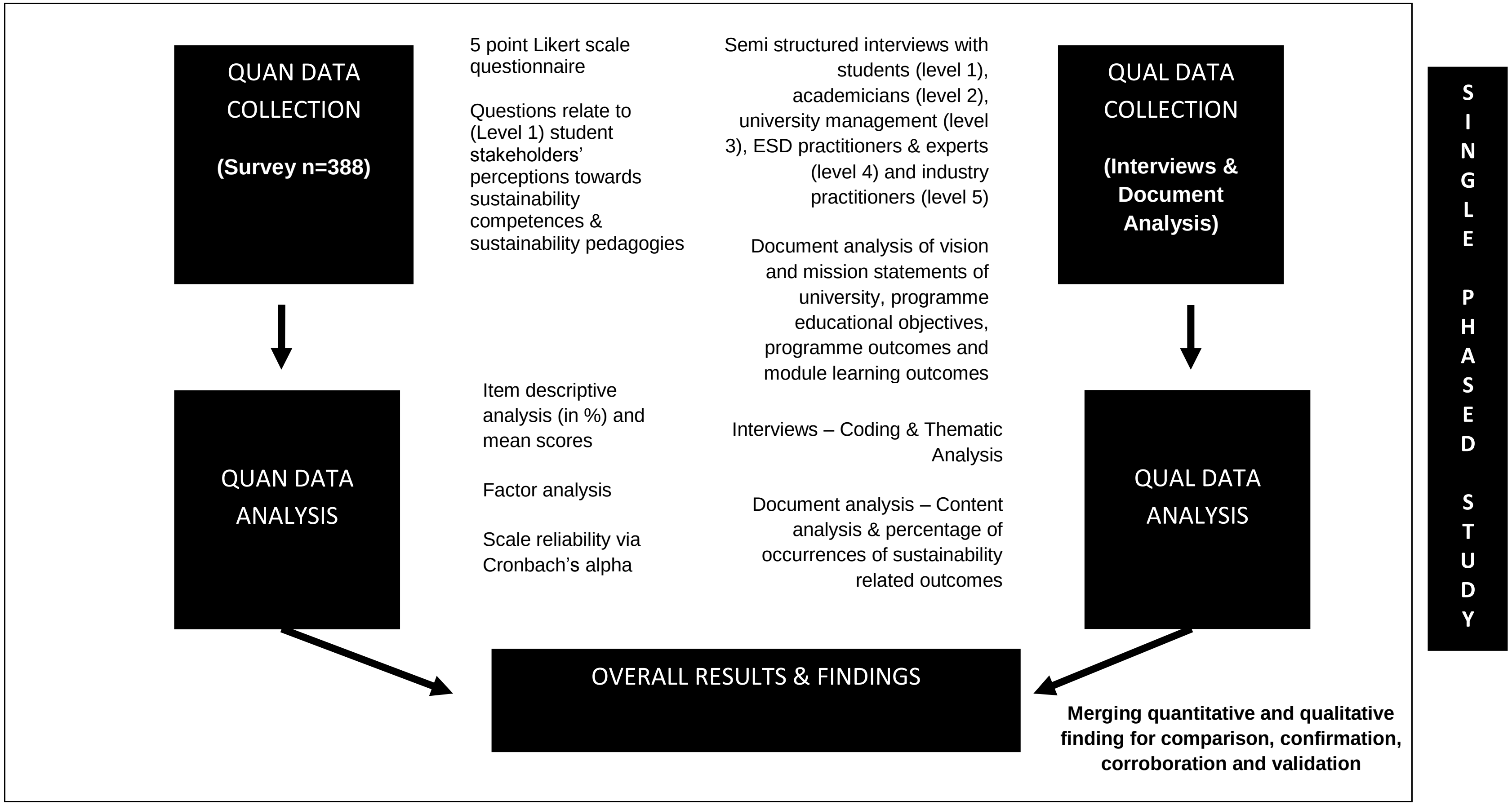


Figure 3.1: Research design

Figure 3.1 illustrates the research design of the present study, based on the triangulation mixed methods design discussed above. The design of this study is unique as it does not conform to a single triangulation variant, but blends two variants of the triangulation design, namely the convergence and multilevel models.

In this study, the convergence triangulation model variant was employed to compare and contrast the quantitative results from the survey with the qualitative findings from the interviews and analysis of documents such as the mission and vision statements, programme educational objectives, programme outcomes and module learning outcomes. Using the convergence model, I was able to collect and analyse concurrently, but separately, the survey, interviews and document analysis data, to obtain a better understanding of the research problem under study. The quantitative and qualitative data sets were then converged or merged by bringing together the separate results of the survey, interviews and document analysis in the overall interpretation. In this study, the convergence triangulation model not only gave me the opportunity to compare results, but also enabled me to use the quantitative and qualitative results obtained to arrive at 'well substantiated' (Creswell & Plano Clark, 2007) conclusions about the issues under study.

As my study also focuses on different levels of higher education stakeholders the multilevel model has also been employed to enable me to look into the manner in which the different levels of stakeholders viewed the issues I sought to explore, namely roles as sustainability advocators in the higher education context, sustainability competences and the engineering workplace, institutional and engineering industry perspectives on sustainability and engineering graduates, pedagogies and curriculum to achieve and support sustainability education goals, as well as issues to consider for the incorporation of ESD within the undergraduate engineering programme.

Using the multilevel triangulation model approach, I used different data collection strategies to address the different stakeholder levels within the study. A survey and interviews were used at the student stakeholder level (level 1) to collect data. At the academicians (level 2), university management (level 3), ESD practitioners and experts (level 4) and engineers from the industry (level 5) levels, interviews were used to gather data. Findings from each level were compared for similarities and differences across the levels. The results from the quantitative and qualitative data sources were then merged together to form the overall interpretation. The convergence – multilevel blend is a reflection of the use of multiple perspectives to better understand the issues studies. In addition, this blend has also resulted in this study becoming more rigorous.

It must be noted that the triangulation design is not the only design available for use in mixed methods research. Other mixed methods designs include the embedded design, the explanatory design and the exploratory design (Creswell & Plano Clark, 2007). The present study however does not fall under any of these above mentioned mixed methods categories. This is due to the following reasons: (a) this study does not aim for one data set to provide a secondary role in a study based primarily on the other data type, as in the embedded design, (b) this study does not aim to use qualitative data to build upon the initial quantitative results using two phases of data collection, as in the explanatory design and (c) this study does not aim to use the results of the first method to develop the second method, as in the exploratory design. Given this rationale, the triangulation mixed methods design which blends the convergence and multilevel models is thus the best approach to answer the research aims and research questions of the present study. The following section will discuss data collection in mixed methods research and issues associated with the collection and analysis of mixed methods data.

3.3 Data Collection approach

Data collection takes place once the research design of the study is established, and the relevant research instruments are designed and piloted. The procedures for data collection differ according to the type of research design used in the study, be it quantitative, qualitative or mixed methods. Differences also occur within the mixed methods design realm, given the varied mixed methods designs available. According to Creswell & Plano Clark (2007), an approach to conceptualizing data collection for a mixed methods design study is to consider data collection according to its type, i.e. either concurrently or sequentially.

Concurrent data collection is also primarily used in triangulation or embedded mixed methods design studies (Creswell & Plano Clark, 2007). In studies which use concurrent data collection, quantitative and qualitative data are collected around the same time. Sequential data collection is used when either the quantitative or qualitative is collected first. The results of the first approach are used to build upon the second data collection approach. The sequential approach is commonly used in explanatory, exploratory and embedded mixed methods designs (Creswell & Plano Clark, 2007). The present study which is a triangulation mixed methods design study employed the concurrent data collection approach.

Several data collection issues come to play in concurrent data collection. These include the selection of participants, the question of sample size, and the manner of approaching results that are contradictory (Creswell & Plano Clark, 2007). During the course of the present study, I had also encountered issues related to participant selection, sample size and contradictory results. I managed these issues in the following manner:

a. Selection of participants

The issue was whether to use the same or different participants for the quantitative and qualitative data collection. According to Creswell & Plano Clark (2007), there is no evident agreement on this issue in literature. However, most researchers use the same participants for their quantitative and qualitative data collection. For the present study, it was decided that the same participants would be used for the quantitative and qualitative data collection. The rationale behind this choice was the design of the study. As the study employed a triangulation design, the use of the same participants for the quantitative and qualitative data collection would result in data that could be converged easily.

b. Sample size

The issue in question was whether the same number of participants was to be used for both quantitative and qualitative data collection. In triangulation mixed methods designs, the issue of sample size is important to converge and differentiate the quantitative and qualitative data sets in the best manner. According to Creswell & Plano Clark (2007), the size of the qualitative sample will typically be smaller than the size of the quantitative sample in a study which employs concurrent data collection. In the present study, the size of the quantitative sample (n=388) was bigger than the qualitative sample (n=35). It has been recommended that increasing the number of qualitative participants would be useful in addressing the issue of sample size. However, this could jeopardize the depth of the information obtained. To counter the issue of the qualitative sample size, the present study elicited multiple perspectives during qualitative data collection. Multiple perspectives were gathered using various qualitative tools, namely interviews with different levels of stakeholders, which were conducted face to face and through e-mail exchanges, document analysis and expert reviews. The multiple qualitative perspectives provided rich information and also explained contradictions that occurred.

c. Contradictory results

Contradictory results are a common occurrence in triangulation mixed methods designs (Creswell & Plano Clark, 2007). Contradictions occur when the quantitative and qualitative findings do not converge. To counter contradictory results, the multiple forms of qualitative data collected through interviews, document analysis and expert reviews proved useful.

3.4 Data collection methods: Survey, Interviews and Document Analysis

In this mixed methods study, both quantitative and qualitative data were collected to address the research questions of the study. Quantitative data was collected through a survey while the qualitative data was gathered through interviews and analysis of documents. The survey was administered exclusively to the student group respondents.

Interviews were conducted to explore the perspective of the students as well as the rest of the respondent groups, namely the academicians, university management, ESD experts, ESD practitioners and industry practitioners. As the study employed a concurrent approach, both quantitative and qualitative data were collected separately, but at the same time.

Table 3.1 describes in detail the data collection methods used to answer the research questions of the study. Following the table is a discussion of the three data collection methods used.

Table 3.1: Research Questions Vs Instruments

No	Research Question	Instrument/s used
1.	To what extent is sustainable development and ESD incorporated within the engineering curriculum of the higher learning institution?	Survey, Document Analysis & Interviews
2.	What are the stakeholders perspectives in terms of : a) the inclusion of sustainable development content within the undergraduate engineering curriculum?	Survey & Interviews
	b) the inclusion of the hypothetical sustainable development competences in the curriculum?	Survey & Interviews
	c) the new sustainable development competences that should be incorporated in the curriculum?	Survey, Interviews & Document Analysis
	d) how sustainable development and ESD competences should be incorporated within the curriculum?	Survey & Interviews
3.	Based on the stakeholders' views, ESD experts' reviews, ESD practitioners' views and literature on ESD, what should the additional components of the EESD framework for Malaysian undergraduate engineering education be?	Interviews

3.4.1 The Survey

This mixed methods study was carried out using quantitative and qualitative means. The quantitative portion of this study was carried out using a survey, and was targeted only at the student respondent group. The survey was used for the student respondent group as I wanted to obtain the information I sought for the study from a larger population. The survey was the most suitable tool as it provided me with the opportunity to obtain the information I needed. According to Fraenkel & Wallen, survey research is one of the most common methods used in educational research (2000). The survey is particularly useful in engaging the opinions of a group of individuals of a certain issue. The survey used in the present study was a directly administered questionnaire. The direct administration method was found to be most suitable, given the fact that it enabled a high response rate, did not cost much, was quicker to administer and presented me with the opportunity to explain and clarify any doubts the respondents had, prior to answering the questions posed in the questionnaire.

The survey for the present study was aimed at the student stakeholders. Its constructs were developed based on an international and local review of ESD literature and frameworks. Issues explored via the surveys included sustainability competences for the engineering workplace, pedagogies & curriculum to achieve and support sustainability education goals, as well as the relevance of the hypothetical sustainable development competences for the undergraduate engineering programme. Gender, age group, nationality and programme of study were not essential variables in this study as it is not the aim of this study to explore student stakeholders' perspectives through these various categories, but rather as one concerted stakeholders' voice.

Likert scales were used as I wanted to determine the students' opinions and attitudes on the questions posed in the questionnaire. As the sole purpose of conducting the survey was to gauge perceptions, the data obtained from the survey was used for the purpose of understanding and describing the final year undergraduate engineering students' views. The survey was made up of three sections. Section A sought the respondent's background information. Section B consisted of a list of common courses, specifically the common engineering, business / management, language / communication and social science and humanities courses. Respondents had to fill in Section B by acknowledging if they had either completed the courses or were currently registered for the courses. Section C consisted of seven sub-sections. Section C was the core section of the questionnaire, as it was through this section that the issues of the present study were explored. These issues included (a) sustainability competences students deem as important to enable them to become sustainability competent engineers when they graduate, (b) sustainability competences students deem as necessary to be included as learning outcomes of engineering modules, non-engineering modules (language and communication, business and management and university level programmes, (c) the forms of teaching methods employed by academicians in the undergraduate engineering programme and (d) teaching and learning issues to be considered in the engineering and non-engineering courses to help develop student's desired sustainability learning experience in the university.

3.4.1.1. Pilot study of questionnaire

Before embarking on the actual data collection process, a pilot study was first conducted. The purpose of conducting the pilot study was to determine if there were any ambiguities with the questionnaire. The pilot study also helped me determine the time I would need to allocate for the actual data collection process. The pilot study was conducted with 35 students who were not the actual respondents of the study. The following issues were brought to the attention of the pilot study respondents for their comments: (a) unfamiliar terms, (b) clarity of language used, (c) clarity of instructions posed, (d) length of questionnaire, (e) aesthetics, i.e. font size, font type, spacing.

The pilot respondents brought up two issues during the pilot study. These issues were the length and the aesthetics of the questionnaire. Respondents noted that the problem with Section C, part (d) of the questionnaire was not the number of questions posed, but rather the repetitive manner in which the questions were written in. This was due to the fact that there were 5 sub-sections which repeatedly sought respondents' feedback on the importance of the inclusion of 30 sustainable development competences within various undergraduate engineering programme modules. To counter this setback, I redesigned this section by merging the five sub-sections into one. This reduced the length of the questionnaire considerably.

The second issue respondents brought up was the font size I had used in the questionnaire. Respondents noted that the font size was rather small causing them discomfort while reading the questionnaire. The small font used was strenuous to their eyes. This problem was rectified by making printing the questionnaire on a full sized A4 paper in booklet form, rather than as a half A4 sized booklet as given out to students during the pilot.

A quick analysis was run on the data obtained from the pilot study. The data collected was analysed using the SPSS version 16 software. Descriptive statistical analysis was carried out using the data obtained from the pilot study. Descriptive analysis was carried out to determine missing values. The indication of missing values suggests that there could be a problem with the manner in which a particular question was posed. As there were no missing values found during the pilot study data analysis, the statements in the questionnaire were retained as it were.

3.4.1.2. Reliability and validity

Reliability and validity are important features of quantitative research. Reliability refers to the 'consistency of a measure of a concept' (Bryman, 2001: p. 70) while validity refers to the 'an indicator or set of indicators that is devised to gauge a concept really measures a concept (Bryman, 2001: p.72). In the present study, the Cronbach's alpha internal reliability test was conducted using data obtained from the questionnaire using the SPSS version 19 software. In relation to validity, face validity and convergent validity methods were used to determine the validity of the questionnaire indicators. Face validity was established by requesting a Professor of Social Learning and Sustainable Development who is a UNESCO chair in the same field, for his expert review on the indicators I developed. Convergent validity was also established through the collection of interview data. Interviews were conducted with academicians, industry practitioners, ESD practitioners and two additional ESD professors from the United Kingdom and Malaysia respectively to gauge their views on the indicators.

The next section will discuss the qualitative methods used in the present study.

3.4.2 Semi-structured interviews

The qualitative data for this mixed methods study was obtained via two means, namely interviews and document analysis. The discussion in this section will encompass the interview approach used in the present study. The document analysis method will be discussed in section 3.6.3.

Interviews are a very important method of data collection as it enables the researcher to determine accuracy, confirm and also counter findings obtained from other sources (Fraenkel & Wallen, 2000). Interviews are conducted to discover how individuals feel and think about certain issues. Noted Patton (2002), the goal of interviewing is to allow the researcher to 'enter into the other person's perspective' (p.341). He further adds that interviews 'begin with the assumption that the perspective of others is meaningful, knowable and able to be made explicit' (p.341). Citing the example of a programme evaluation interview, Patton notes,

> 'Programme evaluation interviews, for example, aim to capture the perspectives of the programme participants, staff and others associated with the programme. What does the programme look and feel like to the people involved? What are their experiences in the programme? What thoughts do people knowledgeable about the programme have concerning programme operations, processes, and outcomes? What are their expectations? What changes do participants perceive in themselves as a result of their involvement in the programme?' (p.341)

Patton's example above bears close resemblance to the present study. In the present study, I too attempt to understand the perspectives of the different levels of stakeholders of a Malaysian undergraduate engineering programme, on the development of an ESD framework for engineering education that incorporates engineering, language/ communication, management, social science and humanities perspectives. The use of interviews will thus enable me to understand the perspectives of the different levels of stakeholders better.

States Bryman (2001), interviews are the most widely used method in qualitative research. There are several types of interviews used in research. These are structured or standardized interviews as it is also known, semi-structured interviews, unstructured interviews or intensive or ethnographic or qualitative interviews as it is also known, focus group or focused interviews, oral history interviews and life history interviews and retrospective interviews (Bryman, 2001, Lofland & Lofland, 1995, Spradley, 1979, Fraenkel & Wallen, 2000, Mason, 2002). Nevertheless, Bryman notes that the three most common interview types often used in research are the structured, unstructured and semi-structured interviews.

Structured interviews, which are also known as standardized interviews is a type of interview that involves the interviewer administering an interview schedule. The interview schedule usually consists of closed-ended questions and is often used as a survey research. Structured interview questions are also rather focused and interviewers usually read out the questions to the interviewees in the exact manner and order. This is to allow for aggregation (Bryman, 2001) of response by the interviewees. In unstructured interviews, researchers use guides known as ‘aide memoirs’ (Bryman, 2001, p.314) to explore the topic being investigated. Unlike the structured interview which usually contain many questions, unstructured interviews could only contain one question. The interviewee is given the opportunity to respond to the question as they deem appropriate. Interviewers follow up on interviewees’ responses which they feel are worthy of being explored further (Bryman, 2001).

Semi-structured interviews on the other hand, are conducted using an interview guide that consists of questions or topics to be covered during the interview. Unlike the structured interview which makes it compulsory for the interviewer to pose his or her questions in a specific order, this is not necessarily the case for semi-structured interviews. The interviewer also has the opportunity to pose questions which are not in the interview guide, especially when the researcher discovers new issues brought up by the interviewee during the interview process (Bryman, 2001). Semi-structured interviews are useful in obtaining data that can be compared, state Fraenkel & Wallen (2000), as participants answer the same questions. This approach also helps reduce interviewer bias in addition to facilitating the organization and analysis of the data obtained (Patton, 1990).

In the present study, I have used semi-structured interviews with open-ended questions to explore the issues under study, instead of using structured or unstructured interviews. Semi-structured interviews were chosen as the preferred type of interview as it facilitated an interviews process which was not too rigid. As I had a reasonably clear focus of the issues I wanted to explore, the semi-structured interview process presented me with the possibility of addressing more detailed issues. Also, as my study involves multiple levels of respondents, the need arises for me to be able to compare respondents’ perspectives across the different levels. The semi-structured interview format enabled me to make these comparisons in a more organized manner.

In addition to the semi-structured interview format, the manner in which interview questions are formulated also play an essential role in determining the success of the interview process. Notes Kvale (1996), there are nine types of interview questions, namely Introducing questions, Follow-up questions, Probing questions, Specifying questions, Direct questions, Indirect questions, Structuring questions, Silence and Interpreting questions. Patton (2002) on the other hand identified six types of interview questions, namely background or demographic questions, knowledge questions, experience or behaviour questions, opinion or values questions, feelings questions and sensory questions.

The interview questions for the present study were thus formulated based on Kvale's (1996) and Patton's (2002) types of interview questions. In situations where the interview guide did not include the above question cues in written format, the cues were verbally communicated to the interview participants during the interview process. The common cues used verbally during the interview process were the follow-up, probing, specifying and interpreting questions.

In the present study, interviews were conducted for the following purposes: (a) To explore engineering and non-engineering academicians, final year undergraduate engineering students and university management perspectives and beliefs on ESD and how they relate these perspectives to engineering programme outcomes, technical and non-technical module learning outcomes as well as pedagogies to achieve ESD goals within the engineering curricula, (b) to explore ESD practitioners' perspectives and beliefs on sustainable engineering and how these perspectives can be incorporated as aspects of ESD within engineering programmes and (c) to explore ESD practitioners' and experts perspectives and beliefs on sustainable development and ESD and how these perspectives can be incorporated within engineering programmes. Using the above general aims of the interview as the guiding framework, the interview questions developed were focused upon the following broad categories explored through the study, namely, (a) roles as sustainability advocators in the higher education context, (b) sustainability competences and the engineering workplace, (c) institutional and engineering industry perspectives on sustainability and engineering graduates, (d) pedagogies & curriculum to achieve and support sustainability education goals and issues to consider for the incorporation of ESD within the undergraduate engineering programme.

3.4.2.1 Interview preparation

As interview guides plays an important role in interviews which are semi-structured in nature, preparation was vital to ensure that the interview sessions took place with minimal disturbance. The following measures advocated by Bryman (2001) were taken into account in preparation of the interviews for the present study: (a) the interview topics and questions were formulated within a certain order: questions were not too specific, acknowledgement of the fact that the order of questions could be altered, so as not to be too rigid, (b) interview questions were formulated using language suitable to the intended audience namely students, academicians and engineering professionals: jargons related to sustainable development and ESD were avoided as much as possible, but when the need arose for these jargons to be used, the meaning of the terms were explained to the respondents, (c) respondents' details were collected prior to the interview sessions using a respondent background information form, (d) interview location and setting was determined prior to the interview: all interviews were held within the premises of the respondents place of work or study, locations selected were usually the respondent's office room or an empty office room, (e) familiarizing myself with the interviewer qualities suggested by Kvale and Bryman, namely, knowledgeable, structuring, clear, gentle, sensitive, open, steering, critical, remembering, interpreting, balanced and ethically sensitive, (f) the use of a digital audio recorder to tape all interviews, (g) the use of a note book to write notes during the interview session, and (h) sending out interview questions via e-mail (Kvale,1996; Bryman, 2001) to respondents whom I was not able to meet for a face to face interview session, as well as to follow up on issues which needed further clarification.

3.4.2.2 Pilot study: Interview Guide

In addition to the steps above, I also conducted a pilot interview with the student and academician stakeholders prior to the actual interview sessions. The pilot interviews gave me the opportunity to assess the clarity and appropriateness of my interview questions, determine the suitability of the language I had used to formulate the questions, time the length of the interview session and practice my own interviewing skills. I had initially planned for the student interviews to be a group interview. The pilot interview was thus conducted in this manner. The 50 minute pilot interview was recorded using a digital audio recorder. The session went on well and the four students who took part in the pilot interview said that they faced no problems understanding the questions I posed to them. They also commented that the language used in the interview guide was easy to understand. However, there were instances in which they sought clarification of certain terms used. I provided them with the necessary information they required and added this information to the interview guide as well. Questions that were repetitive were also removed from the interview guide.

However, when I asked them if they found the group interview session interesting, they explained that they would rather be interviewed individually as they felt that at the moment they had more to say, another interviewee would jump into the conversation mid-way to talk about the same issue. This was a source of irritation for them. The pilot interview respondents also shared with me that given the packed semester schedule of the students, it would be impossible for me to group them together as their free periods differed. Taking these issues into consideration, I decided upon semi-structured individual interviews for the actual data collection process.

The academician pilot interview was an individual face to face interview session. The pilot session lasted about 25 minutes. The comments that I obtained from the pilot interviewee was similar to the comments I received from the students. She noted that the questions were easy to understand and that the language used was appropriate for the intended target respondents. She also suggested that I remove some questions as they were repetitive. While she understood the issues I was attempting to explore, she cautioned me that there could be a possibility that some academicians may not be familiar with certain terms I used during the interview. An example would be my use of the term sustainability education instead of ESD. Although both terms are used interchangeably, I decided to use the term ESD which is more commonly used. The necessary changes were made accordingly in the interview guide.

3.4.2.3 Validity and Credibility

In qualitative research, validity is viewed as a primary criterion for accessing the quality of a study, rather than reliability. Validity in qualitative research refers to ‘the honesty, depth, richness, and scope of the data achieved, the participants approached, the extent of triangulation and the disinterestedness or objectivity of the researcher’ (Cohen et al. 2000: 105). Researchers like Lincoln and Guba (1985) prefer using credibility instead of validity, when referring to the credibility of the research findings. Other researchers use the term trustworthiness. Several measures have been suggested to enhance the credibility. These include respondent or member validation, triangulation, the use of thick description, the use of audit trails, prolonged engagement in the field and researcher reflexivity (Silverman, 2001; Bryman, 2001, Guba and Lincoln, 1989).

In the present research, interviews were supplemented with document analysis and survey findings for the purpose of triangulation. Thick description was achieved through the detailed description of the research context, the participants, and the procedures to ensure a comprehensive understanding of where the study was conducted, who the study was conducted with and the manner in which it was conducted. Researcher reflexivity was also described to explain the researcher-participant relationship and my role as a researcher in the study. The aspect of researcher reflexivity is elaborated further in section 3.5.2.4.

3.4.2.4 Interviewer-Interviewee relationship

As the present study is a mixed methods study which includes a qualitative component, the issue of reflexivity warrants discussion. Due to the fact that humans are the primary instrument in qualitative research, the possibilities for data collection and analysis to be sieved through the researcher’s ‘worldview, values and perspectives’ (Merriam, 1998, p.22) are always present. Through reflexivity, the consideration of the self in relation to the research, as well as an account of the research choice are suggested. Mauthner and Doucet (2003), explain that practicality and visibility are important when dealing with qualitative means of inquiry. They further state that reflexivity focuses on the implications of the researcher's stance on their analytic and interpretive slant to carrying out research and communicating the findings of their research. Strauss and Corbin (1990) also explain that researchers must be aware of assumptions that could interfere with their ability to conduct a systematic and analytical interpretation.

The aims of my study were to describe and explore perspectives and beliefs of higher education stakeholders. As a pragmatic researcher, I subscribe to the notion that the manner in which individuals construct meaning is linked to their experiences. Thus, to be able to comprehend how the research participants made meaning of the issues we discussed in the interviews, it was necessary for me to view the world through the eyes of the participants. I therefore assumed the role of a participant observer to enable my understanding of the participants' views.

The issue of power relations in an education setting was also considered thoroughly. Note Scott and Usher (1999), interview participants usually provide responses based on the setting and their role. As a result, the possibilities of a student respondent proving views could be that of a student answering a teacher's question. I was fortunate as I did not face such a predicament. The student and academician participants I interviewed saw me as a researcher and not as a lecturer. This could have been due to the measures I had taken to establish rapport. Furthermore, I was always conscious to maintain an informal and casual demeanour during the interviews. Through these means, I managed to obtain honest opinions and rich data that I believe would not have been possible, had they positioned me as a lecturer.

To limit my assumptions and researcher subjectivity, effort was put to ensure that the data collection procedure was rigorous. In addition to collecting multiple sources of data, I also ensured that biasness, as a result of my assumptions did not surface. This was achieved through several means, namely cross-checking interview data with participants to ensure that it was the participants' voices that surfaced, and not mine. The next section will discuss the document analysis component, the additional qualitative component used in this mixed methods study.

3.4.3 Document analysis as secondary data

Documents have been used as sources of data in much research. Notes Bowen (2009), there has been an increase in the use of documents as a form of data in many research reports and journal articles. Document analysis entails the systematic procedure of reviewing documents. Data obtained from the review of documents are deciphered to draw out meaning, gain understanding and develop empirical knowledge (Corbin & Strauss, 2008). Document analysis is also useful as a source of triangulation. A variety of documents can be used for the purpose of document analysis. These include books, newspaper clippings, journals, diaries, minutes of meeting, textbooks, policy documents, magazines, songs, speeches and almost any form of communication. The analysis is usually of the written contents of the communication (Fraenkel & Walen, 2000).

The term content analysis is often used to describe analysis of this nature. Content analysis can be pursued in two ways, namely through its manifest content or its latent content. However, the best method is to use both forms if possible (Fraenkel & Wallen, 2000). The manifest content of a communication refers to the 'obvious, surface content-the words, pictures, images, and so on that are directly accessible to the naked eye or ear' (Fraenkel & Wallen, 2000, p. 475). An example would be to count the number of times a certain word appears in the particular type of content. Latent content refers to the underlying meaning of the communication. An example would be to read through the whole communication and assess the extent to which the issue investigated is present in the communication.

The interpretation of content analysis data is commonly conducted through the counting of 'frequencies and percentages or proportions of particular occurrences to the total occurrences (Fraenkel & Wallen, 2000, p. 475). A base or reference point for counting must also be recorded (Fraenkel & Wallen, 2000, p. 477) to enable comparisons to be made against the counted occurrences. In the present study, document analysis was used as a means of triangulating the results of the other data sources used in the study, particularly the interviews. Documents analysed included the following: (a) vision and mission statements of the higher learning institution, (b) undergraduate engineering programme educational objectives and programme outcomes and (c) common engineering and non-engineering module learning outcomes. The results obtained from the document analysis were used to compare the results of the analysis of interviews with the academician and university management stakeholder levels.

Both manifest and latent content of the documents were analysed. The base or reference points for the analysis were manifest and latent content in relation to sustainable development and ESD competences in: (a) the vision and mission statements of the institution of higher learning, (b) the various undergraduate engineering programme educational objectives and programme outcomes, against the sustainability competences in the Malaysian Engineering Accreditation Council's (EAC) engineering programme accreditation criteria and (c) the common engineering and non-engineering module learning outcomes against the percentage of sustainability competences present in the undergraduate engineering programme educational objectives and programme outcomes of the various engineering programmes the particular module is offered in at the university.

3.5 Minimizing threats to mixed methods research validity

A mixed methods study also warrants a discussion of the overall validity of the design. Validity is an important element within any form of research. According to Creswell & Plano Clark (2007), mixed methods research validity can take on the types usually related with quantitative and qualitative research. Nevertheless, it is also important to address the validity of the overall mixed methods design. The term 'inference quality' or 'legitimation' is often used to describe validity in mixed methods research. The term 'inference quality' is used by mixed methods proponents like Tashakkori & Teddlie while the term 'legitimation' is used by other mixed methods writers like Onwuegbuzie & Johnson. Creswell & Plano Clark retain the term 'validity' as it is used in both quantitative and qualitative research. For the purpose of this research, the term 'validity' will be used in the discussion, instead of 'inference quality' or 'legitimation'.

Creswell & Plano Clark (2007) define mixed methods research validity 'as the ability of the researcher to draw meaningful and accurate conclusions from all of the data in the study' (p. 146). They further assert that validity in mixed methods research is discussed from the perspective of the overall design. As such in a triangulation design, validity is established if the researcher uses different data sets, rather than using a single data set. This type of validity was termed by Creswell in the year 2004 as 'consequential' or 'triangulation validity' (p.146).

Measures were taken to ensure that threats to research validity had been dealt with accordingly in this study, namely, (a) using the same participants for the quantitative and qualitative data collection, (b) addressing contradictory data through the use of multiple perspectives, (c) ensuring that the quantitative and qualitative approaches address the same question. Through the use of these measures, the potential threats to the validity of the present concurrent design study could be minimised, in addition to enhancing the rigour of the study.

3.6 Research Site

The present study adapted a case study approach and was conducted at a private Malaysian university located in Perak from July 2011 to February 2012. As mentioned in the official website of the university, there are two faculties in the university, namely the Faculty of Engineering and the Faculty of Science and Information Technology. The Faculty of Engineering consists of the Department of Chemical Engineering, Civil Engineering, Electric and Electronic Engineering and Mechanical Engineering. There is also a Department of Management and Humanities in the university, but it does not offer any undergraduate or postgraduate programmes at present. The department is made up of three units, i.e. language and communication unit, the business and management unit and the social science and humanities unit. Modules related to these three areas are offered to students to fulfil their respective programme curriculum requirements. Common engineering and non-engineering modules students need to take are offered in the English Language.

3.7 Case study research

A case study can be described as a form of empirical investigation which seeks to explore a phenomenon within its real-life context (Yin, 2003). A case study can also be defined as an in-depth and thorough examination of a single case (Bryman, 2001). Case studies can be conducted on individuals, communities, schools and even organization. The study can be conducted as a single case study, i.e. on a particular person or community, a particular school or a particular organization (Bryman, 2001). It can also be conducted as a multiple case study, i.e. on a certain number of individuals, schools or organizations.

According, to Bryman (2008), there are four types of case studies. These are the critical case, which can be used to test a hypothesis, the unique case, which is a case that is extreme or cannot be repeated, the revelatory case, which is used to investigate an issue that has never been examined before and the exemplifying case, which is used to exemplify or embody a usual or typical situation of the time. The case studied in the present research can be described as an exemplifying case study. The exemplifying case is usually chosen to 'exemplify a broader category of which it is a member' (Bryman, 2008, p. 56). An exemplifying case study is also undertaken 'because they either epitomize a broader category of cases or they will provide a suitable context for certain research questions to be answered' (Bryman, 2008, p.56).

In the present study, the university discussed had been identified as the exemplifying case to study. As the university offers undergraduate engineering programmes in line with the requirements of the Engineering Accreditation Council, this makes it a member of the broader group of Malaysian universities which offer undergraduate engineering programmes accredited by the Engineering Accreditation Council. This membership makes it possible for the university to be used as an exemplifying case study for the present research. In addition to this, the university's recent introduction of sustainable development to its research agenda and academic outcomes provides a unique opportunity to gain insight into the participants' perceptions of the university's move, further making it a fitting context for me to search for the answers to issues I seek to explore in the present study.

3.8 Gaining access to the research site

Obtaining access to the research site is a crucial step in data collection. Before I started my data collection process, I first wrote to the Vice Chancellor of the university to seek his permission for me to conduct my research in the university. The purpose of the research and the manner in which data would be collected was explained.

In addition to obtaining the Vice Chancellor's permission, I also communicated with Heads of Departments to notify them about my study and data collection efforts. I was given verbal permission to conduct my data collection with the potential research participants who were a part of the Departments. I made it clear to them that all data obtained would not be divulged and that confidentiality would be maintained at all times.

The next step was gaining access to the research participants. Before collecting data from them, participants were informed of the purpose of the study, and the manner in which data would be collected from them. I also explained to them the benefits of them participating in the study, in addition to assuring them of the confidentially measures I would take. I also explained to all participants that they would be given pseudonyms to safeguard their anonymity. Participants were also assured that they were free to withdraw from the study at any point of time, if they wished to do so. After this verbal explanation, I gave them the Research Information Sheet to read and the Participant Consent Form to sign. These measures helped me gain the trust of the participants.

3.9 Ethical Issues

For the purpose of this study, ethical clearance documentation was submitted to the University of Nottingham, School of Education Research Co-ordinator for approval in June 2011. Data collection commenced in July 2011 upon ethical approval. Prior to the commencement of data collection, all participants were clearly notified of the purpose of the research, the manner in which the research would be conducted as well as the risks that may be involved. A research information sheet was also given to participants for them to read. The research information sheet contained the title of the research, a summary of the research and the researcher’s contact details. Once participants had read through and understood the research information sheet, written consent was obtained from them. A participant consent form was given to all participants for them to read and sign. The participant consent form contained several statements pertaining to data collection, confidentiality and data protection. Participants who agreed to be part of the research were asked to sign the participant consent form.

3.10 Conclusion

This chapter presented the methodology used in the present study. Issues discussed included the research design of the study, the research instruments, the pilot study phase, as well as the research site. Ethical considerations pertaining to data gathering were also included in the discussion. The chapter that follows presents the analysis and results of the data gathered for the present study.

CHAPTER 4

RESULTS OF STUDY

PART 1: ANALYSIS OF DATA

4.0 Introduction

Chapter 4 focuses on the results of the study. The results are later converged in Chapters 5 to 7 to answer the research questions. Prior to discussing the results of the data analysis, information on the respondents of the study, as well the approach taken in the analysis of the survey, interviews and document analysis will first be discussed.

4.1 The respondents of the study

The primary participants of the study were the stakeholders of the university. The respondents were made up of final year undergraduate engineering students, academicians, namely the engineering, language and communication, business and management, social science and humanities academicians, members of the university's top management committee as well as practitioners from the Malaysian engineering industry. ESD practitioners and ESD experts were also interviewed to obtain additional input.

As the present study attempts to understand perspectives on the development of an ESD framework for engineering education in Malaysia that incorporates engineering, language/ communication, management, social science and humanities perspectives, it was vital for me to include the final year undergraduate engineering students, the academicians, members of the university's management, ESD practitioners and engineers from the Malaysian engineering industry. These varied stakeholder perspectives provided a more comprehensive understanding of the issues I sought to explore in the study.

Prior to data collection, respondents were briefed on the purpose of the study and the manner in which their views would aid the purpose of the study. Participants were also assured the confidentiality of their true identities. Upon the acceptance of the terms of the data collection process, participants signed a participation consent form to indicate their agreement to be respondents of the study.

4.1.1 Survey respondents

A total of 388 final year undergraduate engineering students took part in the survey. The rationale for conducting the survey with final year students was because they were almost finishing their studies and would thus have a better understanding of the whole engineering curriculum over the period of their four years of study at the university. There was a population of 1046 students in their final year of the undergraduate engineering programme at the time the survey was conducted. This figure was obtained from University X's Academic Registration Unit.

Purposive sampling was used for the present study. Given the requirement of this study of having respondents to have completed taking all common undergraduate modules prior to graduation, not all 1046 students qualified to be respondents. Additionally, many of them had also obtained transfer of credits from University X for having taken similar modules at their diploma level before enrolling at University X. This group of students was not selected as respondents. There were also students who had not attended their internship training. They too were excluded as a result.

After this screening stage, 706 respondents were finally identified by the Academic Registration Unit as eligible to answer the questionnaire. These students were then tracked down with the assistance of University X's Registry Department and student representatives. 706 questionnaires were distributed to the respondents through the student representatives. 397 were returned, denoting a 56.2% response rate. Of the 397 returned questionnaires, nine were removed due to incomplete responses. This left the total useable questionnaires at 388. To achieve a 95% confidence level, a 5% margin of error and a question choice selected by 50% of the sample, the minimum recommended sample size for this study was 282 respondents. The 388 responses received therefore surpassed the required number needed by 106 respondents.

There were 248 male and 140 female students who responded to the survey. This gender imbalance was reflective of the overall male-female student ratio of the university as a whole, where students of the engineering programmes were mostly male. The respondents comprised of 372 Malaysian students and 16 international students from Middle Eastern, African and Asian nations. Respondents ranged between the ages of 20-26, with the most number (94.1%) of the respondents within the 21-23 age range. All 388 responses that were used for the analysis belonged to final year undergraduate engineering respondents who had completed or were taking modules from the common engineering, university requirement, English and communication, and the social science, humanities and national requirement list of modules offered by in the undergraduate engineering programme. This was in compliance with the student stakeholder criteria of the study which required only final year undergraduate engineering students as respondents. As the above modules are usually completed before the final year of studies at the university, participants would be able to comment on the outcomes of these modules as they would have taken, or were presently taking them. The 388 respondents were from all five engineering programmes in the university, namely Electric and Electronic Engineering (EE), Chemical Engineering (CHEM), Civil Engineering (CV), Mechanical Engineering (MECH) and Petroleum Engineering (PET).

4.1.2 Interview respondents

A total of 34 respondents were interviewed for this study. The students, academicians, members of the university's higher management, ESD experts and practitioners and professionals of the engineering industry respondents were purposively selected for the interview sessions. The following criteria were used to purposively select the academicians, university management, ESD experts and practitioners and engineering industry respondents: (a) respondents who have experience teaching or coordinating basic, intermediate and advanced level common engineering modules within the engineering programme, (b) respondents who have experience teaching or coordinating common language, communication, business, management, social science and humanities modules within the engineering programme, (c) respondents with specific experiences and expertise on ESD, (d) respondents from the university management who hold specific experiences on the university's academic and research agendas with respect to sustainable development , (e) respondents of different levels of designation from the engineering industry who implement sustainable engineering practices, (f) respondents from the engineering industry whose engineers consist of those who graduated from a Malaysian engineering programme. As the study employed a triangulation design, the use of the same student participants for the survey and interviews was necessary to enable the data to be converged. Students were purposively identified for the interview sessions based on the following criteria:

a) Malaysian and International undergraduate engineering students
b) Must be in the final year of their undergraduate engineering programme
c) Must have completed all common undergraduate engineering modules
d) Must have completed their industrial training
e) Must have answered the survey administered for the present study

Snowballing was used to identify potential student respondents. Interviews with students were conducted to the point of saturation. 13 students of the 388 students who took part in the survey agreed to be interviewed. However, only five of them were able to commit to the interview session. The remaining interviewees, who had initially agreed to be interviewed, had later backed out of the interview session. However, this was not too detrimental to the study as interview saturation had been attained with the fifth interview respondent. A brief profile of the interview respondents is as presented in Table 4.1.

Table 4.1: Interviewee Profile According To Respondent Level

LEVEL 1 FINAL YEAR UNDERGRADUATE ENGINEERING STUDENTS			
INTERVIEWEE ID	**GENDER**	**PROGRAME**	**NATIONALITY**
S1	Male	Petroleum	Malaysian
S2	Female	Mechanical	Malaysian
S3	Female	Civil	Malaysian
S4	Male	Electric & Electronic	International
S5	Female	Chemical	Malaysian

LEVEL 2: ACADEMICIANS			
INTERVIEWEE ID	**GENDER**	**PROGRAME/ DESIGNATION**	**NATIONALITY**
A1	Male	Chemical/ Assoc Prof	International
A2	Male	Civil/ Assoc Prof	Malaysian
A3	Female	Mechanical/ Lecturer	Malaysian
A4	Male	Civil/ Senior Lecturer	Malaysian
A5	Female	Management & Humanities/ Lecturer	Malaysian
A6	Male	Management & Humanities/ Assoc Prof	Malaysian
A7	Female	Management & Humanities/ Lecturer	Malaysian
A8	Female	Management & Humanities/ Senior Lecturer	Malaysian
A9	Female	Management & Humanities/ Lecturer	Malaysian
A10	Male	Electric & Electronic/ Senior Lecturer	Malaysian
A11	Male	Management & Humanities/ Senior Lecturer	American
LEVEL 3: UNIVERSITY MANAGEMENT			
INTERVIEWEE ID	**GENDER**	**DESIGNATION**	**NATIONALITY**
U1	Male	VC	Malaysian
U2	Male	Director of Student Services	Malaysian
U3	Male	Senior Manager Academic Central Services	Malaysian
U4	Male	Head Management & Humanities Department	Malaysian
LEVEL 4: ESD EXPERT & PRACTITIONERS			
INTERVIEWEE ID	**GENDER**	**DESIGNATION**	**COUNTRY**
EP1	Male	Professor & UNESCO Chair	Netherlands
EP2 (E-mail response)	Male	Professor	UK
EP3	Male	Professor	MALAYSIA
EP4	Male	Professor	UK
EP5	Male	Professor	UK
EP6	Female	Assoc Prof	UK
EP7	Female	Lecturer	INDIA/UK

EP8	Male	Professor	UK
EP9 (E-mail response)	Female	Professor	UK
LEVEL 5: INDUSTRY PRACTITIONERS			
INTERVIEWEE ID	**GENDER**	**DESIGNATION**	**COUNTRY**
IP1	Male	Institution of Engineers Malaysia Chairman of Branch	Malaysia
IP2	Male	Senior Technical Manager	Malaysia
IP3	Male	Operations Director	Malaysia
IP4	Male	Engineering Consultant	Malaysia
IP5 (E-mail response)	Male	Assistant Manager Process & Product Development	Malaysia
IP6	Male	Managing Director	Denmark

The next section discusses the approach used in the analysis of the data obtained from the survey, interviews and document analysis.

4.2 Data analysis approach

Data analysis involves the examination of the data collected during the process of data collection. Note Creswell & Plano Clark (2007, pp.129), the procedure for data analysis is primarily achieved using five steps. These are the preparation of the data sets for analysis, exploring data, analysing the data, representing the data analysis and validating the data. These five steps are discussed in relation to the present study. Quantitative data is in reference to the data obtained from the survey, while qualitative data is in relation to the data obtained from the interviews and document analysis. The analysis for the present study was conducted using the procedures prescribed by Creswell & Plano Clark (2007).

Step 1: Preparation of the data sets for analysis

Quantitative data: Data coding, cleaning up the database, recoding or computing new items for analysis and establishing a codebook

Qualitative data: Organization of documents, transcribing interviews into word files and preparing the documents and interview transcripts for data analysis

Step 2: Exploring data

Quantitative data: Examining the data visually, performing descriptive analysis, inspecting for trends and distributions

Qualitative data: Reading through the data, writing memos and developing a qualitative codebook

Step 3: Analysing the data

Quantitative data: Determining the mean and standard deviation, analysing the results to answer the research questions

Qualitative data: Coding the data, labelling the codes, grouping codes into themes or categories, interrelating themes

Step 4: Representing the data analysis

Quantitative data: Representing results in the form of percentage, mean scores, statements of results and providing results in tables

Qualitative data: Representing the findings in the form of discussions using codes and themes

Step 5: Validating the data

Quantitative data: Using external standards, validating and checking the reliability of scores from past instrument use, establishing validity and reliability of current data

Qualitative data: Using researcher, participant, and reviewer standards, employing validation strategies such as researcher reflexivity, member validation and triangulation

As the present study used the concurrent approach, the quantitative and qualitative data were analysed separately and later merged. Two data merging techniques are available for the merging of quantitative and qualitative data, namely the data transformation technique and the discussion or matrix technique (Creswell & Plano Clark, 2007). The present study uses the discussion technique instead of the data transformation or matrix technique.

Using the discussion technique, and where appropriate, the quantitative results, i.e. the descriptive results are followed up with qualitative results using quotations or explanation of the category/ theme that either 'confirms or disconfirms the quantitative results' (Creswell & Plano Clark, 2007, p. 140). The order could also be inverted, where the qualitative results are followed up with quantitative results (Creswell & Plano Clark, 2007). Additionally, qualitative results from the document analysis are also used to confirm or disconfirm the quantitative or qualitative results obtained from the survey and interviews. The sections that follow discuss the data analysis approach for the different data sources used in the present study, namely the survey, the interview and the document analysis.

4.3 The Survey

The focus of the discussion will be Section C of the survey. This is the section of the survey which aimed to uncover final year undergraduate engineering students' views on the incorporation of sustainability competences in the undergraduate engineering programme. Section C contains seven sub-sections in total. Of these seven sub-sections, sections (a), (c) and (d) were based on the 30 hypothetical competences. Labelled as sustainability competences in the survey, the competences were developed based on the review of literature and frameworks on sustainable development competences and ESD discussed in Chapter 2. The list of 30 competences developed was also validated by a Netherlands based UNESCO Chair in Social Learning and Sustainable Development. The competences relate to the sustainability literacies engineering students need to be exposed to, to enable them to practice, appreciate and understand sustainable development and sustainable engineering upon graduation. These 30 competences are:

1. Understand people's relationship to nature
2. Hold appropriate understanding of how the economy, society and environment affect each other
3. Hold personal understanding of the environment which is derived from direct experience

4. Local to global understanding of how people continuously impact on the environment
5. Understand how science and technology has changed nature and people’s effect to the environment
6. Understand how cultural and social values influence how resources are viewed
7. Analyse a sustainability issue creatively, critically and systemically using scientific, social science and humanities approaches
8. Able to consider present and future directions of society and environment, and personal role and contribution to the future
9. Think of a holistic approach to solving an engineering problem
10. Think of a holistic approach to solving real life complex problems
11. Able to participate in groups consisting individuals from many fields or disciplines of study to jointly evaluate causes, put forward and work out problems, and provide solutions to problems
12. Apply engineering skills to solve real life sustainability problems facing society
13. Apply language and communication skills to solve real life sustainability problems facing society
14. Apply business and management skills to solve real life sustainability problems facing society
15. Apply social science and humanities concerns to solve real life sustainability problems facing society
16. Able to critically reflect on own assumptions and assumptions of others
17. Able to critically reflect on issues on a personal and professional level
18. Able to manage and direct change at individual and social levels
19. Able to express personal responses to environmental and social issues
20. Ability to demonstrate and articulate sustainability related values such as care, respect, charity, social and economic justice, commitment, cooperation, compassion, self-determination, self-reliance, self-restraint, empathy, emotional intelligence, ethics and assertiveness
21. Play the role of responsible citizens at the local and global level for a sustainable future

22. Develop appreciation of the importance of environmental, social, political and economic contexts of engineering processes for sustainability
23. Consider implications of engineering processes in relation to the environment
24. Consider implications of engineering processes in relation to the society
25. Consider environmental issues in relation to the society
26. Appreciation of all living entities
27. Appreciation that current actions can impact on the quality of life of future generations
28. Respect and value cultural, social and economic and biodiversity
29. Appreciation of the variety of approaches to sustainability issues
30. Appreciation for the need for lifelong learning in relation to sustainability issues and change

The sub-sections of the survey, in which these competences are explored, are: Sub-section (a): The importance of the 30 competences for students to become sustainability competent engineers, Sub-section (c): The extent to which the 30 competences are presently given importance in the undergraduate engineering programme, and Sub-section (d): The extent to which students viewed the 30 competences as important for engineering students to learn in their engineering, English language, communication, management, social science and humanities courses and university level programmes to prepare them for the engineering workplace when they graduate. A five point Likert scale was used to obtain respondents' views for these three sub-sections. Likert scales were used as I wanted to determine the students' opinions and attitudes on the competences listed. The scale used was an importance scale. The five points of the Likert scale denoted 1, for very unimportant, 2, for somewhat unimportant, 3, for neither important nor unimportant, 4, for somewhat important and 5, for very important.

Sub-sections (b), (e) and (f) of the survey were not in relation to the hypothetical competences. Instead, these sub-sections were designed to seek respondents' views as follows: Sub-section (b): Views on the present forms of teaching methods employed by academicians in the undergraduate engineering programme, Sub-section (e): Views on the importance of sustainability education as undergraduate students and future engineers, Sub-section (f): Views on the manner in which sustainable development input could be provided in the undergraduate engineering programme, Sub-section (g): Views on teaching and learning issues that needs to be considered in the engineering and non-engineering modules to help develop the desired sustainability learning experience in the university. Five point Likert scales were used for sub-sections (b), (e) and (f). Sub-sections (b) and (f) had scales denoting 1 for strongly disagree, 2 for disagree, 3 for undecided, 4 for agree and 5 for strongly agree. Sub-section (e) had scales denoting 1, for very unimportant, 2, for somewhat unimportant, 3, for neither important nor unimportant, 4, for somewhat important and 5, for very important.

4.3.1 Results of pilot study and expert reviews of the hypothetical competences

The pilot study was conducted using responses from 35 respondents. A reliability analysis was conducted for the 30 competences from the questions from sub-sections (a), (c) and (d). Assert Hair et al (1998), the generally agreed upon alpha lower limit for Cronbach's alpha is 0.70. However, this value may decrease to 0.60 in exploratory research. The reliability analysis values from the pilot study for the three questions are as listed below:

a) Sub-sections (a) – 0.90
b) Sub-section (c) – 0.89
c) Sub-section (d) Engineering - 0.94
d) Sub-section (d) English language/Communication – 0.85
e) Sub-section (d) Management/Business – 0.95
f) Sub-section (d) Social Science/Humanities – 0.95
g) Sub-section (d) University programmes – 0.96

Although it was a newly developed scale, and given the exploratory nature of the present study, all alpha values for the above listed sub-sections were nevertheless above the 0.70 cut off point stated by Hair et al, making it highly reliable. As a result, all 30 competences for all sub-sections were thus retained. Although the pilot study Cronbach alpha values indicated the items for the three sub-sections were highly reliable, I believed it was also important to determine the validity of the items prior to the actual data analysis process. An expert review was carried out to determine the face validity of the 30 items. This expert review was conducted by a Netherlands based Professor of Social Learning and Sustainable Development, who is also a UNESCO chair in the same field. Given his familiarity with the Malaysian engineering education scenario, and the outcome based education system, his review of the 30 competences was instrumental for the development of the final framework within the Malaysian context. His review indicated that the 30 hypothetical competences were appropriate and fitted quite well as programme and module learning outcomes. He nevertheless cautioned me that when categorizing the competences as I have, there was a risk of coming up with too many competences, and this may not be ideal. However, he noted that competences could serve as a foundation to assist stakeholders in recognizing the literacies related to sustainability. I was also advised to use the term competence, for the development of the final framework.

In addition to the expert review by the UNESCO Chair, a second and third international review of the 30 competences was also conducted to seek further views on the manner in which the competences could be improved for the development of the final framework. These second and third reviews were conducted by two Professors in the field of ESD from the University of Plymouth and the University of Gloucestershire in the United Kingdom, where sustainability is a core university mission and strategy.

The fourth review was from the local expert, who is a Professor from the university in which the present study took place. His association with the university proved useful as he was able to review the 30 competences from the context of the university's engineering education programme. Although he did not mention the need to label the items as competences, his review indicated that the competences were applicable to the societal and nationhood issues discussed in relation to sustainable development from a Malaysian context.

The results from the pilot reliability analysis and expert reviews enabled me to proceed with the actual data analysis process. Upon collection of the actual data, a second reliability analysis was conducted for sub-sections c (a), (b), (c) and (d). Actual data alpha values recorded for these sub-sections were all above the cut-off point stated by Hair et al. (1998): Sub-sections (a) – 0.949, Sub-sections (b) – 0.914, Sub-section (c) – 0.961, Sub-section (d) Engineering - 0.949, Sub-section (d) English language/Communication – 0.960, Sub-section (d) Management/Business – 0.958, Sub-section (d) Social Science/Humanities – 0.956, Sub-section (d) University programmes – 0.968

The data obtained from the survey was then used for the purpose of quantitatively exploring the final year undergraduate engineering students' attitudes on the incorporation of sustainability competences in the undergraduate engineering programmes offered by the university. In line with the convergence triangulation design of the study, the quantitative findings from the survey were later converged with the qualitative results of the study to form the overall interpretation of the data analysed.

4.4 The Interview

To explore the issues of the present study further, the views of Malaysian engineering education stakeholders', namely students, academicians, university management and the engineering industry are seen as important to enable the development of the framework. The views of ESD practitioners and experts are equally significant to ensure that the exploration of the constructs necessary for the development of the framework is as inclusive as it can be. As described in Chapter 3, data collection for this mixed methods study was conducted using quantitative and qualitative means. The previous section discussed the survey analysis approach used in the study. This section will focus on the interview analysis approach of the study.

4.4.1 An overview of the interview aims and respondents

This section will focus on the approach used in the interview data analysis. As detailed in the Methodology chapter, all interviews that were conducted for this study took place from July 2011 to February 2012. The interviews lasted between 50 minutes to an hour on average. Interviews were the main qualitative data collection method used in the study, while document analysis provided additional input. The purpose of the interview sessions were to: (a) explore engineering and non-engineering academicians, final year undergraduate engineering students and university management perspectives and beliefs on ESD and how they relate these perspectives to engineering programme outcomes, technical and non-technical module learning outcomes as well as pedagogies to achieve ESD goals within the engineering curricula, (b) explore perspectives and beliefs of engineers from the industry on sustainable engineering and how these perspectives can be incorporated as aspects of ESD within engineering programmes, (c) explore ESD practitioners' and experts perspectives and beliefs on sustainable development and ESD and how these perspectives can be incorporated within engineering programmes.

The interview questions developed were focused upon participants' views on sustainability, pedagogies to achieve and support sustainability education goals, sustainability education support, issues to consider for the incorporation of sustainability within the undergraduate engineering programme and most importantly, their views on the hypothetical ESD competences which were drawn upon competences engineering students would need to be able to practice, appreciate and understand sustainability effectively upon graduation.

4.4.2 Preparation of interview data for analysis

There were a total of 33 interviews transcribed. All interviews were transcribed verbatim in Ms Word format. Transcription symbols were used in the transcripts to indicate overlapping speech, silence, pauses, word emphasis and inaudible word or phrases. The symbols used are as listed below:

[	Starting point of overlapping speech
]	End point of overlapping speech
(2.4)	Silence measured in seconds

(.)	Pause of less than 0.2 seconds
<u>Word</u>	Emphasis
( )	Inaudible, i.e. words or phrases that could not be heard clearly or made sense of

All interviews were conducted in English, as agreed by the respondents. In instances in which respondents used languages other than English, these words, phrases and expressions were transcribed in its original form to preserve the essence of the expression.

4.4.3 The interview codebook

This section describes the interview codebook for the analysis of the interviews conducted with the 33 respondents. The interview questions revolved around broad categories in relation to roles as sustainability advocators in the higher education context, sustainability competences and the engineering workplace, institutional and engineering industry perspectives on sustainability and engineering graduates, pedagogies and curriculum to achieve and support sustainability education goals and issues to consider for the incorporation of sustainability education within the engineering programme. Emerging broad categories and sub-categories were also noted during the course of reading through all transcripts. These emerging categories were later merged within the broad and sub-categories as it was found to be overlapping with the existing categories.

The interview codebook consisted of a total of 29 code numbers in accordance to the sub-categories explored through the interviews. The 29 code numbers were then used in the analysis of the interview transcripts. For instance, an issue related to sustainability in the Malaysian engineering industry was coded as number 27 in the interview transcript, while an issue on support for academicians was coded as number 30. Once the section of the transcript was coded within its code number, the specific word or phrase identified within the section is given a code in the form of a word or phrase. These codes were then transferred to an interview analysis matrix to enable comparison between the respondents of the same category (i.e. academicians vs. academicians) and with respondents from different categories (i.e. academicians vs. industry practitioners). Given the different respondent groups, the use of numbers as codes made the transcription process more systematic. It also made locating the issues highlighted by respondents in the interview transcript easier. Comparing the issues explored by respondent groups was also easier using this system. Overlapping codes were grouped together. Code numbers (14 – teaching sustainable development through language/communication, business, social science and humanities modules), (17 – teaching sustainable development for workplace relevance), (21 -teaching and learning styles for sustainable development) and (22 – challenges to academicians if sustainable development made a compulsory of non-technical modules), which are not accounted for in the table, were merged with the existing code numbers (13), (28), (20) and (23) respectively.

There are several considerations for the coding process and the development of codes from interviews. According to Charmaz (2002), questions that need to be asked when developing codes are 'what is going on? what are people doing? what is the person saying? What do the activities and statements undervalue? How to the structure and context support, preserve, hinder or vary these actions and statements?' (p.675-694). Mason (2002), on the other hand advocates a three levels to analysing qualitative data, i.e. literal, interpretation and reflexive. The literal level entails the identification of words, dialogues used, actions, settings and systems. At the interpretation level, implicit norms, values and rules as well as the manner in which respondents make sense of the phenomena are focused upon. The reflexive level looks into the researcher's role in the process, as well as how this intervention generated data.

Creswell (2003) proposes a six step approach to qualitative data analysis. These steps are 'organization and preparation of data for analysis, reading through the data to obtain a general sense of the information and reflecting on its overall meaning, coding, using the coding process to develop a description of the setting, the people and the themes, explaining the manner in which the themes would be represented in the write up, interpreting or giving meaning to the data' (p. 191-195). Bryman's approach to the coding process involves several stages. These include reading the transcript as a whole, rereading the text and identifying the labels for the codes, coding the text and reviewing the codes and finally relating the general theoretical ideas to the text (Bryman, 2008: p.550-552).

In addition, Bryman's (2008) thematic analysis approach was also used to analyse the interview data. States Bryman, although thematic analysis does not have an 'identifiable heritage' (p. 554) akin to the grounded theory of critical discourse analysis approaches, it is nevertheless one of the most common approaches used in qualitative data analysis. In conducting a thematic analysis for the present study, the Framework approach developed by the National Centre for Social Research, United Kingdom was adapted. Notes Ritchie et al (2003), the Framework approach is a 'matrix based method for ordering and synthesising data' (p. 219). Using the Framework approach, an index of main themes and sub-themes are represented in the form of a matrix. The data from the various respondents are then slotted into the various sub-themes. Ryan and Bernard's (2003) theme identification recommendations were also used to aid the development of themes from the interview data for the development of the matrix. Their suggestions involve looking for repetitions, indigenous typologies or categories, metaphors and analogies, transitions, similarities and differences, linguistic connectors, missing data and theory related material (Ryan and Bernard, 2003).

The interview analysis conducted in the present study was based upon Creswell and Bryman's approaches to qualitative data analysis. Based on the Framework approach, a matrix was also developed to aid the analysis of the 33 interview transcripts. The matrix developed for the present study is as illustrated in Table 4.2.

Table 4.2: Interview analysis matrix

Broad category explored: Pedagogies & curriculum to achieve and support sustainability education goals	Code	Theme
Sub-category 1 : Existing methods of teaching sustainable development/ sustainable engineering and associated teaching & learning concerns (Code number = 1) **Respondent 1:** View of respondent on the issue is extracted from transcript and recorded in this column	1.Main point from extract recorded in this column, in the form of a word or phrase	Theme formed from main points that are related for every sub-issue
Respondent 2: View of respondent on the issue is extracted from transcript and recorded in this column	2. Main point from extract recorded in this column, in the form of a word or phrase 3. Main point from extract recorded in this column, in the form of a word or phrase	
Respondent 3: View of respondent on the issue is extracted from transcript and recorded in this column	4. Main point from extract recorded in this column, in the form of a word or phrase	

As seen in Table 4.2, the matrix developed for the interview data analysis for the present study consisted of three columns, namely the categories explored, the code and the theme that emerges as a result of similar codes grouped together. The first column consists of the categories being explored through the interview sessions with the respondents. The categories explored were developed based on the interview codebook. The views obtained from the respondents are extracted from the interview transcript and added into this column. In the second column, i.e. the code column, the main point or points of the views of the respondents are simplified into words or phrases known as codes. All codes are numbered for ease of reference for comparison between respondents. Once all 33 transcripts were coded, the codes were then grouped under themes in the last column of the matrix.

4.4.4 Interview Analysis Results Overview

This section provides an overview of the results of the interview. The section that follows provides a detailed explanation of the codes and themes derived for each broad category.

4.4.4.1 Overview of codes and themes for each broad category

This section provides an overview of the codes and themes for the five broad categories explored qualitatively in the present study. Table 4.3 represents the total number of codes and themes that emerged from the thematic analysis process.

Table 4.3: Total number of codes and themes derived

Broad category	Sub-category and code number	Codes Total	Number of themes	Themes total by broad category
Roles as sustainability advocators in the higher education context	Professional performance (5)	57	5	8
	Academician role (6)	30	2	
	University Management role (7)	4	1	
Sustainability competences and the engineering workplace	Sustainability competences as a necessity for the engineering workplace (3)	27	2	3
	Application of sustainability competences as an engineer (4)	5	1	
Institutional and Engineering Industry perspectives on sustainability and engineering graduates	The place of sustainability in the higher education context (8)	8	2	9
	Sustainability and the Malaysian engineering industry (27)	33	3	
	Shaping higher education for sustainability nurturing (28)	45	4	
Pedagogies & curriculum to achieve and support sustainability education goals	Existing methods of teaching sustainable development/ sustainable engineering and associated teaching & learning concerns (1)	103	5	
	Institutional Approach to sustainable development (2)	37	5	34

	The relevance of the hypothetical competences (9)	11	1	
	Suggested improvements to the hypothetical competences (10)	18	1	
	Collaborative learning through sharing of knowledge and expertise by engineering & non-engineering lecturers (11)	11	3	
	Communities of Practice as a means of developing better understanding of sustainable development (12)	33	5	
	Non-technical modules (language/communication, business, social science and humanities modules) as a platform for sustainable development competences development (13)	12	2	
	Interdisciplinarity, multidisciplinarity and transdisciplinarity through ESD (15)	10	2	
	Essential knowledge and skills to teach sustainable development (16)	23	1	
	Engineering or non-engineering academicians for the teaching of sustainable development (18)	21	2	
	Methods of providing sustainable development input (19)	9	1	
	Philosophies and styles of teaching & learning for sustainable development (20)	38	6	
Issues to consider for the incorporation of Sustainability Education within	Benefits and challenges to academicians in relation to ways of approaching the teaching of sustainable development & placing sustainable development in the curriculum (23)	49	2	

the engineering programme	Dealing with sustainable development content (24)	17	3	22
	Defining holistic understanding of sustainable development / sustainable engineering (25)	3	1	
	The university-internship-workplace ties in relation to sustainable development (26)	18	1	
	Holistic approach to sustainable development by the university (29)	13	1	
	Support for academicians (30)	32	2	
	Sustainable development opportunity provision besides formal academic input for university stakeholders (students & academicians) (31)	7	1	
	Improving institutional practices for advancement of sustainable development in the university (32)	139	10	
	Development of sustainable development competences for effective practice of sustainable engineering in the workplace (33)	5	1	

A total of 29 code numbers and 818 codes were obtained from the 33 transcripts, representing the academicians, university management, ESD experts, ESD practitioners, industry practitioners and students respondent groups. These codes were then grouped into 76 emerging themes in accordance to its broad categories. A total of 8 themes emerged for the broad category *Roles as sustainability advocators in the higher education context*. Three themes emerged for the *Sustainability competences and the engineering workplace* category. The category *Institutional and Engineering Industry perspectives on sustainability and engineering graduates* had nine themes, while *Pedagogies & curriculum to achieve and support sustainability education goals* and *Issues to consider for the incorporation of Sustainability Education within the* *engineering programme* had 34 and 22 emerging themes, respectively. The section that follows will present the themes that emerged from the analysis of the interviews.

4.4.4.2 Overview of interview results by broad category

This section describes the results of the interview conducted with the respondents of the present study. The results of the interviews will be presented in accordance to the broad categories and sub-categories listed. The table that follows lists the themes that emerged from the interview analysis. The emerging themes are presented in accordance to the five broad categories and 29 sub-categories explored for the purpose of the present study.

Table 4.4: Emerging themes according to broad and sub-categories

Broad category	Sub-category	Number of themes	List of themes
Broad category 1 Roles as sustainability advocators in the higher education context	Professional performance	5	1. Vague research roles 2. Research performance 3. Management & Humanities academicians within the sustainable development research context 4. Conforming to KPIs 5. Corporate vs. academic culture
	Academician role	2	1. Communicating & instilling importance of sustainable development through research and practice 2. Teaching responsibilities
	University Management role	1	1. Role of university management
Broad category 2 Sustainability competences and the engineering workplace	Sustainability competences as a necessity for the engineering workplace	2	1. University-workplace-family divide 2. Benefits of sustainable development competences for the engineering workplace
	Application of sustainability competences as an engineer	1	1. Sustainable development competences for workplace responsibilities
Broad category 3 Institutional and Engineering Industry perspectives on sustainability and engineering graduates	The place of sustainability in the higher education context	2	1. Malaysian education system 2. Sustainable development and higher education
	Sustainability and the Malaysian engineering industry	3	1. Sustainable development practices within the industry 2. Industry needs 3. Inadequate sustainable development enforcement
	Shaping higher education for sustainability nurturing	4	1. Engagement of Ministry of Higher Education, Engineering Accreditation Council and Industry to improve sustainable development educational outcomes for Malaysian engineering education 2. Issues with present engineering curriculum in the university 3. Ways of addressing sustainable development gaps in the curriculum 4. Sustainable development as a common vision binding university stakeholders
Broad category 4 Pedagogies & curriculum to achieve and support sustainability education goals	Existing methods of teaching sustainable development/ sustainable engineering and associated teaching & learning concerns	5	1. Sustainable development content within Language & Communication modules 2. Unsustainable learning practices 3. Sustainable development & Malaysian higher education 4. Sustainable development in the present undergraduate engineering curriculum 5. Undergraduate research assessment
	Institutional Approach to sustainable development	5	1. Misassumptions on the role & position of Management & Humanities department 2. Top management's role in cultivating sustainable development culture 3. Improvements for the cultivation of sustainable development culture 4. Sustainable development in light of the Research University agenda

			5. Sustainable development and the engineering curriculum
	The relevance of the hypothetical competences	1	1. Relevance of hypothetical competences
	Suggested improvements to the hypothetical competences	1	1. Suggested improvements to the hypothetical competences
	Collaborative learning through sharing of knowledge and expertise by engineering & non-engineering lecturers	3	1. Collaborative sustainable development teaching 2. Professional Communication Skills module as a collaborative teaching & learning platform 3. ETP/FYP research as a collaborative practise
	Communities of Practice (CoP) as a means of developing better understanding of sustainable development	5	1. Management & Humanities academicians readiness in practicing CoP through research 2. CoP through teaching 3. Limitations of the CoP 4. ETP/FYP as a platform for CoP 5. Benefits of CoP
	Non-technical modules (language/communication, business, social science and humanities modules) as a platform for sustainable development competences development	2	1. Sustainable development modules from a non- engineering dimension 2. Sustainable development through multiple perspectives
	Interdisciplinarity, multidisciplinarity and transdisciplinarity through ESD	2	1. Interdisciplinarity, multidisciplinarity and transdisciplinarity within modules 2. Approaching multidisciplinarity
	Essential knowledge and skills to teach sustainable development	1	1. Desired ESD educator qualities
	Engineering or non-engineering academicians for the teaching of sustainable development	2	1. Engineering vs. non-engineering academicians 2. Sustainable development from a non-engineering dimension
	Methods of providing sustainable development input	1	1. Ways of providing sustainable development input
	Philosophies and styles of teaching & learning for sustainable development	6	1. Teaching style preferences 2. Two way communication 3. Sustainable development teaching limitations 4. Present learning limitations 5. Sustainable development assessment 6. Present teaching philosophy
Broad category 5	Benefits and challenges to academicians in	2	1. Sustainable development integration challenges

Issues to consider for the systemic incorporation of Sustainability Education within the engineering programme	relation to ways of approaching the teaching of sustainable development & placing sustainable development in the curriculum		2. Methods of integrating sustainable development in the curriculum
	Dealing with sustainable development content	3	1. Relating SD to engineering and non-engineering modules 2. Sustainable development through Management & Humanities modules 3. Sustainable development through engineering modules
	Defining holistic understanding of sustainable development / sustainable engineering	1	1. Holistic approach to SD
	The university-internship-workplace ties in relation to sustainable development	1	1. Bridging the gap through university-internship- workplace combination
	Holistic approach to sustainable development by the university	1	1. Holistic approach to sustainable development in the university
	Support for academicians	2	1. Professional development for academicians to develop sustainable development awareness and become sustainable development change agents 2. Applicability of ESD teaching guidelines/framework
	Sustainable development opportunity provision besides formal academic input for university stakeholders (students & academicians)	1	1. Non-academic sustainable development input
	Improving institutional practices for advancement of sustainable development in the university	10	1. Academicians role in embracing change towards advancement of sustainable development 2. Sustainability culture & awareness as a concerted institutional practice 3. Policy vs. Practice 4. Top down approach to sustainable development management 5. Limitations of middle management 6. Planning, implementation and monitoring as sustainable development enforcement initiatives 7. Issues stifling sustainable development promotion 8. Communicating sustainability to university stakeholders 9. Sustainable development & undergraduate learners 10. Tackling resistance to sustainable development

	Development of sustainable development competences for effective practice of sustainable engineering in the workplace (33)	1	1. Desired competences for effective practice of sustainable engineering at the workplace

Using evidence in the form of quotations from the various respondent groups, these themes will be discussed in further detail findings of the present study are converged according to the study's research questions in Chapters 5 to 7.

4.5 Document analysis

According to the United Nations Economic Commission for Europe (UNECE) (2011), there is a need to distinguish between sustainable development competence and ESD competence. Sustainable development competence illustrates an individual's ability to contribute to sustainable living within professional and personal capacities. ESD competence on the other hand is the educator's ability to assist people in developing sustainable development competence using innovative teaching and learning approaches. This section therefore discusses the extent to which sustainable development and ESD competences have been included within the institution's educational vision and mission statement, the current undergraduate engineering programme educational objectives, programme outcomes and common module learning outcomes, using the document analysis approach. Manifest and latent analysis of these documents was based on the manifestations of sustainable development competences and ESD competences within the documents analysed.

Manifest content refers to the words that are explicitly present in the text and are 'directly accessible to the naked eye or ear' (Fraenkel & Wallen, 2000: p. 475), while latent content is in reference to the implicit or underlying meaning present in the text. The base or reference points for the analysis were as follows: (a) manifest and latent content in relation to sustainable development and ESD competences in the vision and mission statements of the institution of higher learning the present study is based upon, (b) manifest and latent content related to sustainable development and ESD competences in the various undergraduate engineering programme educational objectives and programme outcomes, against the sustainability competences in the Malaysian Engineering Accreditation Council's engineering programme accreditation criteria, (c) manifest and latent content related to sustainable development and ESD competences in the common engineering and non-engineering module learning outcomes against the percentage of sustainability competences present in the undergraduate engineering programme objectives of the various engineering programmes the particular module is offered in at the university. The second half of this chapter will now proceed with the presentation of the results of the data analysis.

PART 2: RESULTS OF ANALYSIS

4.6 Results of data analysis

This section presents the results of the data analysis. Table 4.5 maps the source of the data analysis results against the issues explored in the present study. The "X" represents the source of the results for the issue explored.

Table 4.5: Issues explored vs. source of results

ISSUES EXPLORED	RESULTS		
	Survey	**Interview**	**Document analysis**
Roles as sustainability advocators in the higher education context		X	
Sustainability competences and the engineering workplace	X	X	
Institutional and Engineering Industry perspectives on sustainability and engineering graduates	X	X	X
Pedagogies & curriculum to achieve and support sustainability education goals	X	X	X
Issues to consider for the systemic incorporation of Sustainability Education within the engineering programme	X	X	X

As evident, not all issues are explored using all three sources of data. The results for the issue *Roles as sustainability advocators in the higher education context,* is obtained solely from the interview session with the various levels of respondents. The results for the issue *Sustainability competences and the engineering workplace* on the other hand has been obtained from two sources of data, the survey and interviews. The results of the three remaining issues have all been gathered using all three data sources. The use of multiple data sources, through surveys, interviews and document analysis, and the various levels of respondents, i.e. academicians, university management, ESD experts, ESD practitioners, engineering industry practitioners as well as students allows for convergence of data for triangulation.

The following sections present the results of the data analysis in accordance to the five issues explored. It must be noted at this juncture that these sections will only present the results obtained from the analysis of data collected for the present study. The interpretation of these results will be presented in detail in Chapters 5 to 7, where the findings of the survey and document analysis are discussed, with accompanying evidence (quotations) from interviews.

4.6.1 Data analysis results for issue 1: Roles as sustainability advocators in the higher education context

The first issue explored is the roles played by the stakeholders as sustainability advocators in the higher education context. Qualitative data was gathered through interviews to gain more insight into the issue. *Roles as sustainability advocators in the higher education context* is an exploration of the respondents' views on the roles they see their individual selves, other academicians, as well as university management playing, into putting sustainable development into effect for the undergraduate engineering student population at the university. This issue also sought respondents' perspectives on the university's introduction of sustainability as a research agenda, and the manner in which it featured within their teaching and research endeavours at the university. This issue was made up of three sub-issues, namely professional performance, academician role and university management role. Themes are as detailed in Table 4.4.

4.6.2 Data analysis results for issue 2: Sustainability competences and the engineering workplace

Sustainability competences and the engineering workplace is the second issue explored in the present study. This issue sought respondents' perspectives on several concerns. The first concern addressed respondents' views on the importance of sustainability input when they become sustainability competent engineering graduates ready for entry into the engineering workforce. The second concern focused upon the sustainable development competences necessary for engineering graduates to enable them to contribute effectively to the engineering industry's sustainable development initiatives when they enter the engineering workforce. The final issue was aimed at gauging the respondents' perspectives on the benefits of sustainable development competences for workplace responsibilities. Both quantitative and qualitative approaches were employed to obtain data for this issue. The survey and interviews were thus used to shed light on the respondents' perspectives on these concerns. The results of the survey are presented first. This is followed by the results of the interviews.

4.6.2.1 Issue 2 - Survey results

This section presents the results of the survey for the issue *Sustainability competences and the engineering workplace*. Two sections of the survey provide the desired information to better understand this issue, namely question C (e) and C (a).

4.6.2.1.1 Final year undergraduate engineering students' responses on the importance of sustainability input to become sustainability competent engineering graduates ready for entry into the engineering workforce

This section presents the results of section C (e) of the survey. Section C (e) gauged respondents' views on two competences, namely, the importance of sustainability input for their present status as undergraduate engineering students (item a) as well as to become sustainability competent engineering graduates ready for entry into the engineering workforce (item b). As *sustainability competences and the engineering workplace* is aimed at exploring sustainability competences and the engineering workplace, the results of item b has been the only results taken into account to understand this issue better. A five point Likert scale was used to gauge respondents' views. A value of 1 denoted very unimportant, 2, for somewhat unimportant, 3, for neither important nor unimportant, 4, for somewhat important and 5, for very important.

14.2% of the responses received for the statement on the importance of sustainability input when they become engineering graduates ready for entry into the engineering workforce**,** were for the *somewhat important* category, while 83.2% of the responses were for the *very important* category. The high mean score value of 4.78 recorded for the item indicates the strong importance of sustainability input to become sustainability competent engineering graduates ready for entry into the engineering workforce.

4.6.2.1.2 Sustainable development competences needed to enable undergraduate engineering students to become sustainability competent engineering graduates ready for entry into the engineering workforce

Survey results were also used to find out respondents' views on the sustainable development competences needed to enable undergraduate engineering students to become sustainability competent engineering graduates ready for entry into the engineering workforce. In order to gauge the respondents' views of this issue, a frequency analysis was conducted using data obtained from the 388 questionnaires to gauge respondents' attitudes towards the 30 hypothetical competences.

Table 4.6 illustrates the frequency of responses received. The frequency categories have been labelled as VU, SU, N, SI and VI to indicate very unimportant, somewhat unimportant, neither important nor unimportant, somewhat important and very important, respectively. The five points of the Likert scale denote 1, for very unimportant, 2, for somewhat unimportant, 3, for neither important nor unimportant, 4, for somewhat important and 5, for very important. The mean score of each item indicates the level of importance of the item.

Table 4.6: Responses for sustainable development competences needed to enable undergraduate engineering students to become sustainability competent engineering graduates ready for entry into the engineering workforce

No	ITEM	VU (%)	SU (%)	N (%)	SI (%)	VI (%)	MEAN	SD
1	Understand people's relationship to nature	0.5	2.8	7.0	42.0	47.7	4.34	0.77
2	Hold appropriate understanding of how the economy, society and environment affect each other	1.0	1.3	4.1	40.5	53.1	4.43	0.73
3	Hold personal understanding of the environment which is derived from direct experience	0.5	1.3	12.4	50.8	35.1	4.19	0.73
4	Local to global understanding of how people continuously impact on the environment	0.5	1.8	8.8	38.9	50.0	4.36	0.76
5	Understand how science and technology has changed nature and people's effect to the environment	0.8	1.0	4.1	31.2	62.9	4.54	0.70
6	Understand how cultural and social values influence how resources are viewed	0.5	5.2	18.6	42.5	33.2	4.03	0.88
7	Analyze a sustainability issue creatively, critically and systemically using scientific, social science and humanities approaches	0.8	1.5	12.1	43.3	42.3	4.24	0.78
8	Able to consider present and future directions of society and environment, and personal role and contribution to the future	1.0	2.3	10.6	41.5	44.6	4.26	0.82
9	Think of a holistic approach to solving an engineering problem	0.8	2.6	10.3	36.1	50.3	4.32	0.82
10	Think of a holistic approach to solving real life complex problems	0.8	2.8	12.6	37.4	46.4	4.26	0.84
11	Able to participate in groups consisting individuals from many fields or disciplines of study to jointly evaluate causes, put forward and	1.0	1.3	5.2	31.7	60.8	4.50	0.75

	work out problems, and provide solutions to problems							
12	Apply engineering skills to solve real life sustainability problems facing society	0.8	0.8	7.0	35.6	55.9	4.45	0.73
13	Apply language and communication skills to solve real life sustainability problems facing society	0.8	1.5	10.8	39.2	47.7	4.31	0.79
14	Apply business and management skills to solve real life sustainability problems facing society	0.5	4.6	15.2	47.2	32.5	4.06	0.84
15	Apply social science and humanities concerns to solve real life sustainability problems facing society	0.0	3.9	18.0	48.2	29.9	4.04	0.80
16	Able to critically reflect on own assumptions and assumptions of others	0.3	2.8	16.5	46.6	33.8	4.11	0.79
17	Able to critically reflect on issues on a personal and professional level	0.3	2.3	16.0	46.6	34.8	4.13	0.78
18	Able to manage and direct change at individual and social levels	0.0	3.1	19.3	46.6	30.9	4.05	0.79
19	Able to express personal responses to environmental and social issues	0.5	4.4	17.0	44.8	33.2	4.06	0.85
20	Ability to demonstrate and articulate sustainability related values such as care, respect, charity, social and economic justice, commitment, cooperation, compassion, self-determination, self-reliance, self-restraint, empathy, emotional intelligence, ethics and assertiveness	0.8	2.8	11.6	37.1	47.7	4.28	0.84
21	Play the role of responsible citizens at the local and global level for a sustainable future	1.0	1.3	9.5	42.0	46.1	4.31	0.78
22	Develop appreciation of the importance of environmental, social, political and economic contexts of engineering processes for sustainability	0.3	3.1	12.6	47.4	36.6	4.17	0.78

23	Consider implications of engineering processes in relation to the environment	0.8	1.5	6.7	38.9	52.1	4.40	0.75
24	Consider implications of engineering processes in relation to the society	0.3	2.6	10.3	39.7	47.2	4.31	0.78
25	Consider environmental issues in relation to the society	0.0	2.3	9.0	36.9	51.8	4.38	0.75
26	Appreciation of all living entities	0.3	3.4	12.6	32.2	51.5	4.31	0.84
27	Appreciation that current actions can impact on the quality of life of future generations	0.3	1.5	3.4	35.3	59.5	4.52	0.66
28	Respect and value cultural, social and economic and biodiversity	0.8	1.8	12.4	41.5	43.6	4.25	0.80
29	Appreciation of the variety of approaches to sustainability issues	0.5	2.6	14.2	45.6	37.1	4.16	0.80
30	Appreciation for the need for lifelong learning in relation to sustainability issues and change	0.8	2.8	8.8	39.7	47.9	4.31	0.81

The results suggest that the final year undergraduate engineering students found all 30 hypothetical competences to be important for them to become sustainability competent engineers when they enter the engineering workforce. This is apparent with all 30 hypothetical competences denoting high percentages for the categories *somewhat important* and *very important*. Competences 1, 2, 4,5,8,9, 10,11,12,13, 20, 21, 23, 24, 25, 26, 27, 28 and 30 recorded higher percentages in the *very important* category, rather than the *somewhat important* category. Competences 3, 6, 7, 14, 15, 16, 17, 18, 19, 22 and 29, on the other hand recorded higher percentages for the *somewhat important* category, rather than the *very important* category. Interestingly also, no response has been recorded under the *very unimportant* category for competences 15, 18 and 25.

In terms of the mean scores for the 30 competences, it was found that all 30 competences have a score of 4 and above. The highest mean score of 4.54 was recorded for item 5. The lowest mean score obtained was 4.03 for item 6. The mean scores obtained thus suggest that all 30 competences are within the range of important to very important competences for the undergraduate engineering students to become sustainability competent engineers upon entering the engineering workforce.

4.6.2.2 Issue 2 - Interview results

This section presents results of the interviews aimed at gauging respondents' perspectives on the second issue *Sustainability competences and the engineering workplace*. Interviews were conducted with academicians, university management, engineering industry practitioners and students for the purpose of exploring respondents' views of this issue. The *Sustainability competences and the engineering workplace* issue consisted of two sub-issues. These were *sustainability competences as a necessity for the engineering workplace* and *application of sustainability competences as an engineer.* The themes that emerged from the thematic analysis are as highlighted in Table 4.4.

4.6.3 Data analysis results for issue 3: Institutional and Engineering Industry perspectives on sustainability and engineering graduates

This section describes the results of the third issue explored through the present study, namely *Institutional and Engineering Industry perspectives on sustainability and engineering graduates*. This issue focused on three concerns. The first was the views of the engineering industry and the higher education sector on the position of sustainability within the higher education context. Next, was the place of sustainability within the Malaysian engineering workforce. This was followed by the symbiotic relationship played by the higher education sector and the engineering industry in moulding higher education towards the fostering of sustainability. Data was gathered via quantitative and qualitative means to gauge respondents' perspectives of the above mentioned concerns.

4.6.3.1 Issue 3 - Survey results

This section describes the results of the analysis of the survey administered to the final year undergraduate engineering student respondents of the study. Section C (e) of the survey provided the student views for the study.

4.6.3.1.1 Final year undergraduate engineering students responses on the importance of sustainability input as undergraduate students, and when they become sustainability competent engineering graduates ready for entry into the engineering workforce

Table 4.7 illustrates the final year undergraduate engineering students' responses on the importance of sustainability input for their present state as undergraduate engineering students, and when they become engineering graduates ready for entry into the engineering workforce.

Table 4.7: The importance of sustainability input as undergraduate students and in becoming sustainability competent engineering graduates ready for entry into the engineering workforce

ITEM	STATEMENT	VU (%)	SU (%)	N (%)	SI (%)	VI (%)	MEAN	SD
A	now as an undergraduate student	1.5	1.0	4.6	29.4	63.4	4.52	0.77
B	as a future engineer	1.3	0.3	1.0	14.2	83.2	4.78	0.60

As shown in Table 4.7, in relation to their present identity as undergraduate students, the respondents are of the opinion that sustainability input is of importance to them. 29.4% and 63.4% of the responses received were recorded for the *somewhat important* and *very important* categories accordingly. As sustainability competent engineering graduates ready for entry into the engineering workforce, 14.2% of the responses were for the *somewhat important* category, while 83.2% of the responses were for the *very important* category. These results suggest that the respondents viewed sustainability input as important for their present identity as undergraduate engineering students, as well as in becoming sustainability competent engineering graduates ready for entry into the engineering workforce. The high mean score vales of 4.52 and 4.78 recorded for item A and B respectively, suggests a strong importance for the presence and inclusion of sustainable development within higher education in Malaysia, specifically within the context of engineering education.

4.6.3.2 Issue 3 – Interview results

The interview sessions conducted to explore this issue looked into three sub-issues. These were *the place of sustainability in the higher education context*, *sustainability and the Malaysian engineering industry*, and *shaping higher education for sustainability nurturing*. *The place of sustainability in the higher education context* sub-issue sought to understand the position of sustainability within the context of higher education. It also delved into concerns that could arise in making sustainable development a prominent feature of the Malaysian engineering education curriculum. Respondents interviewed for their views on this sub-issue were the university management as well as an ESD expert.

The second sub-issue looked into views of respondents from the Malaysian engineering industry on the practice of sustainable development within the Malaysian engineering industry. The sub-issue also explored issues faced by the Malaysian engineering industry in advocating for the need for sustainable engineering practices. The level of sustainable development awareness and knowledge possessed by Malaysian engineering graduates was also a concern discussed through this sub-issue.

The final sub-issue within the *Institutional and Engineering Industry perspectives on sustainability and engineering graduates* issue was the manner in which higher education in Malaysia could be moulded to cultivate sustainable development consciousness amongst its stakeholders. The perspectives of university management, Malaysian engineering industry practitioners, ESD experts and ESD practitioners were sought on this sub-issue. Themes are as detailed in Table 4.4.

4.6.3.3 Issue 3 – Document analysis results

The document analysis served as a check and balance measure to corroborate the results of the interviews conducted. The purpose of conducting the document analysis was to establish the extent to which sustainable development had been indoctrinated as an academic philosophy within the university. Documents analysed for this purpose were the university's vision and mission statements, as they represented the foremost academic philosophy of the university. In establishing the extent to which sustainable development is featured within the university's academic philosophy, manifest and latent analysis was conducted on the university's vision and mission statements. The results of the analysis are presented in the sections that follow.

4.6.3.3.1 Sustainability competences in the vision and mission statements of the institution

This section discusses the manifest and latent content related to sustainability competences in the vision and mission statements of the institution of higher learning where the present study took place. Sustainability competences in this thesis refer to sustainable development competences and ESD competences.

4.6.3.3.1.1 Manifest and latent content in Vision and Mission statements related to sustainable development competences

Table 4.8 depicts the vision and mission of the university. The university has also outlined specific vision and mission statements in relation to research that is undertaken. As outlined in Table 4.9, the research vision and mission of the university was also obtained from the university's research website.

Table 4.8: Vision and Mission of the university

VISION
A Leader in Technology Education and *Centre for Creativity and Innovation*
MISSION
University X (anonymous to protect the identity of the institution) is an institute of higher learning. We provide opportunities for the pursuit of knowledge and expertise for the advancement of engineering, science and technology to enhance the nation's competitiveness. Our objective is *to produce well-rounded graduates who are creative and innovative* with the potential to become leaders of industry and the nation. Our aim is *to nurture creativity and innovativeness* and expand the frontiers of technology and education for the *betterment of society*.

Table 4.9: Research Vision and Mission of the university

VISION
University X (anonymous to protect the identity of the institution) has set a vision to become a leader in R & D and consultancy, recognized internationally as a partner of choice for industries, a respected member of scientific communities and an *innovation platform* for the research fraternity.
MISSION
R & D and consultancy is expected to be an integral function of University X that *creates social and economic value* and enhances industrial competitiveness through technology and innovation, by *generating, applying and transferring knowledge*.

As evident in both tables, the vision and mission statements of the university, as well as its research vision and mission do not contain manifest content commonly used to describe competences related to sustainable development. Words and phrases that are frequently used to portray sustainability are not apparent in these statements. Instead, the vision and mission statements seem to be worded within industrial and national development contexts. Nevertheless, phrases such as *for betterment of society* in the vision and mission statement of the university and the phrase *creates social and economic value* in the research vision and mission are latent content in reference to sustainable development competences. The section that follows will describe the results of the analysis of manifest and latent content related to ESD competences within the university's educational vision and mission statements.

4.6.3.3.1.2 Manifest and latent content in Vision and Mission statements related to ESD competence

The document analysis suggests that the vision and mission statements of the university as a whole, and that of the university's research office have not been written within the context of ESD competences. In terms of manifest content, there seems to be little evidence of common ESD phrases such as sustainability education, sustainable education, education for sustainability and ESD or its abbreviated form ESD, used in the statements. However, latent content in reference to ESD competences are present in these statements. Examples of these phrases include *Centre for Creativity and Innovation*, *to produce well-*

rounded graduates who are creative and innovative, to nurture creativity and innovativeness, which are apparent in the vision and mission statements. Phrases such as *an innovation platform*, and *generating, applying and transferring knowledge* from the research vision and mission, are other instances of the latent content present. Although it appears that the latent presence of ESD competences is evident in these vision and mission statements, it may not be accurate to associate these phrases with ESD. This is due to the fact that the context in which the statements were written does not indicate that of ESD.

4.6.4 Data analysis results for issue 4 - Pedagogies & curriculum to achieve and support sustainability education goals

This section describes the results of the fourth issue explored in the study. The issue *Pedagogies & curriculum to achieve and support sustainability education goals* sought to explore respondents' perspectives on concerns such as existing methods of teaching sustainable development or sustainable engineering and its associated teaching and learning concerns. It also looked into the university's present approach to the teaching and learning of sustainable development. This issue also focused on gauging respondents' views on the relevance of the 30 competences as well as ways in which these outcomes could be improved upon for the development of the final framework.

4.6.4.1 Issue 4- Survey results

This section describes the results of the data analysed from the survey administered to the final year undergraduate engineering student respondents. The results of these concerns are presented in the sections that follow.

Section 4.6.4.1.1: Perspectives on the pedagogical approaches practiced at the university at present

This section describes findings from Question (b) of Section C of the survey. The aim of this question was to gauge the final year students' views on the pedagogical approaches currently practiced at the university. More specifically, the questions sought to determine if current pedagogical approaches at the university reflected pedagogies related to ESD. There were a total of 24 items in this question. A five point Likert scale was used to obtain respondents' views. The scale used was an agreement scale. The five points of the scale denote 1, for strongly disagree, 2 for disagree, 3 for undecided, 4 for agree and 5 for strongly agree. The mean score of each item indicates the level of agreement for the items. The responses for question (b) are summarised in Table 4.10.

Table 4.10: Present pedagogical approaches at the university

No	ITEM	SD (%)	D (%)	U (%)	A (%)	SA (%)	MEAN	SD
1	My engineering programme promotes the importance for all students to practice sustainability.	1.0	10.1	18.3	48.5	22.2	3.81	0.93
2	My engineering lecturers discuss the importance for engineering students to practice sustainability through the courses they teach.	1.5	11.1	24.2	46.6	16.5	3.65	0.93
3	My language and communication lecturers discuss the importance for engineering students to practice sustainability through the courses they teach.	5.4	14.7	34.3	33.0	12.6	3.33	1.05
4	My management lecturers discuss the importance for engineering students to practice sustainability through the courses they teach.	3.9	12.9	20.6	42.8	19.8	3.62	1.06
5	My social science/humanities lecturers discuss the importance for engineering students to practice sustainability through the courses they teach.	3.6	10.6	30.4	42.0	13.4	3.51	0.97
6	Engineering and non-engineering lecturers should practice sharing of knowledge on best approaches to teach sustainability to engineering students.	0.0	1.3	6.7	33.5	58.5	4.49	0.68
7	Engineering and non-engineering lecturers should invite each other to their courses, to teach and discuss about sustainability issues and ideas with engineering students.	1.3	4.6	16.8	31.7	45.6	4.16	0.95
8	In my Engineering courses, I need to apply knowledge that I learn in the classroom, to explain engineering issues or problems related to the environment.	0.8	4.4	12.1	45.4	37.4	4.14	0.85
9	In my Language and Communication courses, I need to apply knowledge that I learn in the classroom, to explain engineering issues or problems related to the environment.	2.3	11.9	21.4	40.2	24.2	3.72	1.03
10	In my Management courses, I need to apply knowledge that I learn in the	2.6	12.6	23.5	42.5	18.8	3.62	1.01

	classroom, to explain engineering issues or problems related to the environment.							
11	In my Social Science and Humanities courses, I need to apply knowledge that I learn in the classroom, to explain engineering issues or problems related to the environment.	3.6	11.6	24.0	43.6	17.3	3.59	1.01
12	Engineering courses I have taken/am taking teach me to reflect on issues and new ideas I learnt from real environmental problems, from the perspective of a member of the human race.	0.8	7.2	18.3	51.3	22.4	3.87	0.87
13	Language and communication courses I have taken/am taking teach me to reflect on issues and new ideas I learnt from real environmental problems, from the perspective of a member of the human race.	2.6	17.5	29.4	38.4	12.1	3.40	0.99
14	Management courses I have taken/am taking teach me to reflect on issues and new ideas I learnt from real environmental problems, from the perspective of a member of the human race.	2.1	13.7	25.5	43.0	15.7	3.57	0.98
15	Social science and humanities courses I have taken/am taking teach me to reflect on issues and new ideas I learnt from real environmental problems, from the perspective of a member of the human race.	2.1	12.1	24.7	44.8	16.2	3.61	0.96
16	Engineering courses I have taken/am taking teach me to reflect on issues and new ideas learnt from real environmental problems, from the perspective of a future engineer.	0.8	4.6	7.2	51.0	36.3	4.18	0.81
17	Language and communication courses I have taken/am taking teach me to reflect on issues and new ideas learnt from real environmental problems, from the perspective of a future engineer.	4.4	15.7	24.0	40.2	15.7	3.47	1.07
18	Management courses I have taken/am taking teach me to reflect on issues and new ideas learnt from real environmental problems, from the perspective of a future engineer.	2.3	10.8	21.9	47.7	17.3	3.67	0.96
19	Social science and humanities courses I have taken/am taking teach me to reflect on issues and new ideas learnt from real environmental problems, from the perspective of a future engineer.	2.1	12.9	28.6	40.7	15.7	3.55	0.97
20	During lessons, students from different engineering programmes are given the opportunity to reflect on activities collaboratively (together) to share knowledge as a group.	4.9	13.4	18.3	41.2	22.2	3.62	1.11

21	Learning approaches in this university focus on experiences gained from my direct involvement in a particular learning situation involving environmental issues.	3.6	14.2	31.2	40.2	10.8	3.40	0.98
22	Learning approaches in this university encourage students to apply ideas they have learnt and experienced through real world learning situations involving environmental issues.	3.6	11.6	22.2	46.4	16.2	3.60	1.01
23	Learning activities in this institution require students to be actively involved in their own learning involving environmental issues.	2.1	11.1	24.7	44.8	17.3	3.64	0.96
24	My university promotes the importance for all students to practice sustainability.	3.6	11.9	23.7	39.9	20.9	3.63	1.05

The results from the responses of the final year undergraduate engineering students for item 1 seem to suggest that they agree that their respective engineering programmes do promote the importance for all students to practice sustainability. This is evident through the higher frequency of responses recorded under the agree (48.5%) and strongly agree (22.2%) categories. Nevertheless, there were 18.3% of the students who were unsure if their respective engineering programmes did promote the importance for all students to practice sustainability, while 1.0% and 10.1% of them indicated that they strongly disagree and disagree respectively with the statement. The mean score for this item was 3.81, indicating agreement.

Item 2 also indicated high responses for the agree and strongly agree categories with 46.6% and 16.5% of responses recorded for these two categories. 24.2% of the responses were undecided, 1.5% strongly disagreed while 11.1% disagreed with the statement. The mean score for this item was 3.65, indicating agreement.

Interestingly, the highest number of responses for the third item was for the undecided category, instead of the agree, or strongly agree categories. The frequency of responses for this category was 34.3 %, suggesting final year undergraduate engineering students were unsure if their English language and communication lecturers did discuss the importance for engineering students to practice sustainability in these modules. 33.0% agreed while 12.6% strongly agreed with the statement, while 14.7% and 5.4% responded that they disagreed and strongly disagreed respectively. The mean score for this item was 3.32, indicating disagreement with the statement.

The results of the fourth item indicate that 42.8% and 19.8% of the responses received were for the categories, agree and strongly agree respectively. 20.6% of the responses received were for the undecided category, 3.9% was for strongly disagree and the remaining 12.9% was for the disagree category. The mean score for this item was 3.62, indicating agreement.

For the fifth item, 42.0% of the responses received were for the category agree, 13.4% for strongly agree, 30.4% for undecided, 10.6% for disagree and 3.6% for strongly disagree. The mean score for this item was 3.51, indicating borderline agreement. The results suggest that of the Engineering, English Language and Communication, Management and Social Science and Humanities modules, the percentage of responses received for the undecided category was highest for the English Language and Communication modules. The results thus suggest that final year undergraduate engineering students are of the opinion that their English Language and Communication lecturers are the least to discuss the importance for engineering students to practice sustainability through the English Language and Communication modules. The Social Science and Humanities lecturers were the second least to discuss the necessity for engineering students to practice sustainability through their modules. The results further suggest that the lecturers who discussed it most were the Engineering lecturers, followed by the Management lecturer. These results are reflected in the low mean scores recorded for these items.

The results for item 6 indicate that the respondents were of strong agreement for their engineering and non-engineering lecturers to do so. 58.5% of the respondents strongly agreed with the statement, while 33.5% agreed. 6.7% of them were undecided, while the remaining 1.3 % disagreed. No response was recorded for the strongly disagree category. The 1.3% disagreement suggests the need for the collaboration between the engineering and non-engineering lecturers for the aim of imparting sustainability knowledge to the engineering students. The mean score of 4.49 indicate agreement.

For item seven, only 1.3% and 4.6% of the respondents strongly disagreed and disagreed to this statement, while 16.8% were undecided. The highest percentages were recorded for the categories agree and strongly agree with 31.7% and 45.6% for each category respectively. The mean score of 4.16 indicate agreement to the statement.

Items 8, 9, 10 and 11 sought to gauge respondents' agreement on whether the Engineering, Language and Communication, Management and Social Science and Humanities modules advocated the need to apply knowledge learnt in the classroom, to explain engineering issues or problems related to the environment. For the Engineering modules, the results indicate that 45.4% and 37.4% of the respondents agree that these modules require them to do so. In the case of the English Language and Communication modules, 40.2% and 24.2% of the respondents are is agreement of the statement. The Management courses recorded 42.5% and 18.8% for the categories agree and strongly agree, while the Social Science and Humanities modules recorded 43.6% for agree and 17.3% for disagree respectively. Overall, the results for items 8, 9, 10 and 11 suggest that all four modules do require application of knowledge from the modules to discuss engineering issues or problems in relation to the environment. The mean scores recorded for these four items were 4.14, 3.72, 3.6 3 and 3.59 respectively, indicating agreement.

The next four items, i.e. items 12, 13, 14 and 15 intended to obtain respondents' extent of agreement on whether the Engineering, Language and Communication, Management and Social Science and Humanities modules taught them to reflect upon issues and new ideas they had learnt from real environmental problems. Their responses were to be based upon their perspective as humans, and not as engineering students or future engineers. As apparent in Table 4.13, of the four modules, the Engineering modules recorded the highest frequencies for the agree, and strongly agree categories with a combined agreement of 73.7% for the said categories. This was followed by the Social Science and Humanities modules with a combined agreement of 61%, the Management modules with a combined agreement of 58.7% and lastly by the English and Communication modules with a combined agreement of 50.5%.

The results thus indicate that the English and Communication module content and lecturers were the least to teach engineering students to reflect upon issues and new ideas they had learnt from real environmental problems, from the perspective of a human being. The mean scores recorded for items 12, 13, 14 and 15 were 3.87, 3.40, 3.57 and 3.61 respectively. Item 13 again registered a mean score value below the 3.50 average value, indicating disagreement. This low mean score was also apparent in item 3, indicating the respondents found the English Language and Communication module content and lecturers to be lacking in terms of disseminating the importance of sustainability through these modules.

Items 16, 17, 18 and 19 focused upon respondents' agreement on whether the Engineering, English Language and Communication, Management and Social Science and Humanities modules taught them to reflect upon issues and new ideas they had learnt from real environmental problems, from the perspective of a future engineer. The results once again indicate that the Engineering modules are the most to do so with a combined agreement of 87.3%. This is followed by the Management modules with 65% combined agreement, the Social Science and Humanities modules with 56.4% and lastly the English Language and Communication modules with 55.9%. Overall, the results indicate that the Engineering module content and lecturers were the most to give input on reflecting upon issues and new ideas from real environmental problems, from the perspective of a future engineer. The least to do so were the English Language and Communication module content and lecturers. The results suggest that the English Language and Communication modules seem to pay less attention to the reflection of issues and ideas from real environmental problems from the human and future engineer points of view. These results are once again reflected in the mean score values obtained for these four items. Of the four items, item 17 recorded the lowest mean score (mean = 3.47), with a value lower than the 3.50 average, indicating respondents disagreed that the language and communication modules taught them to reflect on issues and new ideas learnt from real environmental problems, from the perspective of a future engineer.

The highest percentage of frequencies recorded for item 20 were 41.2% for agree, followed by 2.2% for strongly agree. 18.3% of the respondents were undecided, while 4.9% and 13.4% of the respondents strongly disagreed and disagreed respectively. The mean score for this item was 3.62, indicating agreement.

Although the highest frequency, 40.2% was recorded for the category of agree for item 21, 31.2%, the second highest frequency was made up of undecided responses. A combined disagreement of 17.8% was recorded for this item. The mean score for this item was 3.40, indicating disagreement.

The subsequent item, item 22 sought to gauge respondents' agreement on real world learning opportunities. Results for this statement indicate that 46.4% (agree category) and 16.2% (strongly agree category) of the respondents are in agreement that the university does encourage students to do so. However, 22.2% are undecided, while 3.6% and 11.6% of the respondents strongly disagreed and disagreed to the statement. The mean score of 3.60 indicates that respondents agreed to the statement.

Item 23 recorded most responses for the agree category, with 44.8%, followed by 24.7% for the undecided category. 2.1% and 11.1% of the responses received were or the categories strongly disagree and disagree respectively. The mean score of 3.64 indicates agreement.

The results for item 24 indicate that 39.9% of the respondents agreed to the statement, while 23.7% were undecided. These were the highest and second highest frequencies recorded for this statement. Nevertheless, the results also indicate that 3.6% and 11.9% of the responses received were in disagreement that the university promoted the importance for students to practice sustainability. The 3.63 mean score recorded for this item indicted agreement. The next section describes the respondents' views on the extent to which the 30 hypothetical competences are presently given importance in the undergraduate engineering programme.

4.6.4.1.2 Responses for undergraduate engineering students level of awareness of the presence of the 30 hypothetical competences as part of the undergraduate engineering programme at present

This section highlights the results of sub-section (c) of the survey. The intent of this section was to gauge final year undergraduate engineering students' level of awareness of the presence of the 30 hypothetical competences as part of the curriculum of the undergraduate engineering programme offered by the university at present. Table 4.11 illustrates the frequency of responses received for the 30 competences.

Table 4.11: Final year undergraduate engineering students' level of awareness of the presence of the 30 hypothetical competences as part of the undergraduate engineering programme at present

No	ITEM	VU (%)	SU (%)	N (%)	SI (%)	VI (%)	MEAN	SD
1	Understand people's relationship to nature	0.8	4.6	15.2	47.2	32.2	4.05	0.85
2	Hold appropriate understanding of how the economy, society and environment affect each other	1.0	1.3	10.1	51.5	36.1	4.20	0.75
3	Hold personal understanding of the environment which is derived from direct experience	0.3	3.4	17.0	50.8	28.6	4.04	0.78
4	Local to global understanding of how people continuously impact on the environment	0.8	4.1	12.9	51.0	31.2	4.08	0.82
5	Understand how science and technology has changed nature and people's effect to the environment	0.5	2.6	5.7	50.5	40.7	4.28	0.73
6	Understand how cultural and social values influence how resources are viewed	1.0	7.5	24.0	47.2	20.4	3.78	0.89
7	Analyze a sustainability issue creatively, critically and systemically using scientific, social science and humanities approaches	1.0	4.4	16.2	51.0	27.3	4.00	0.84
8	Able to consider present and future directions of society and environment, and personal role and contribution to the future	0.5	3.9	15.5	49.0	31.2	4.06	0.82
9	Think of a holistic approach to solving an engineering problem	0.8	3.9	14.9	46.4	34.0	4.09	0.85

10	Think of a holistic approach to solving real life complex problems	1.0	4.4	17.5	45.9	31.2	4.02	0.87
11	Able to participate in groups consisting individuals from many fields or disciplines of study to jointly evaluate causes, put forward and work out problems, and provide solutions to problems	1.0	3.4	9.8	41.8	44.1	4.24	0.84
12	Apply engineering skills to solve real life sustainability problems facing society	1.0	2.1	10.8	46.4	39.7	4.22	0.80
13	Apply language and communication skills to solve real life sustainability problems facing society	1.8	5.4	18.3	45.6	28.9	3.94	0.92
14	Apply business and management skills to solve real life sustainability problems facing society	1.0	7.0	24.7	44.3	22.9	3.81	0.90
15	Apply social science and humanities concerns to solve real life sustainability problems facing society	1.3	7.2	21.9	47.7	21.9	3.82	0.90
16	Able to critically reflect on own assumptions and assumptions of others	0.3	5.2	17.0	58.0	19.6	3.91	0.77
17	Able to critically reflect on issues on a personal and professional level	0.3	4.6	13.9	55.9	25.3	4.01	0.78
18	Able to manage and direct change at individual and social levels	0.5	4.4	21.1	52.3	22.7	3.91	0.81
19	Able to express personal responses to environmental and social issues	0.5	3.9	19.8	47.9	27.8	3.99	0.82
20	Ability to demonstrate and articulate sustainability related values such as care, respect, charity, social and economic justice, commitment, cooperation, compassion, self-determination, self-reliance, self-restraint, empathy, emotional intelligence, ethics and assertiveness	1.0	3.9	17.3	44.3	33.5	4.05	0.87
21	Play the role of responsible citizens at the local and global level for a sustainable future	0.8	4.4	14.7	46.4	33.8	4.08	0.85
22	Develop appreciation of the importance of environmental, social, political and economic contexts of engineering processes for sustainability	0.5	3.6	13.7	49.5	32.7	4.10	0.80
23	Consider implications of engineering processes in relation to the environment	0.3	3.4	9.8	44.8	41.8	4.24	0.78
24	Consider implications of engineering processes in relation to the society	0.5	3.6	10.8	47.9	37.1	4.18	0.80

25	Consider environmental issues in relation to the society	0.0	3.6	11.3	48.5	36.6	4.18	0.77
26	Appreciation of all living entities	1.0	2.6	15.7	40.5	40.2	4.16	0.85
27	Appreciation that current actions can impact on the quality of life of future generations	0.8	2.3	9.5	42.8	44.6	4.28	0.79
28	Respect and value cultural, social and economic and biodiversity	1.3	4.1	15.2	46.6	32.7	4.05	0.87
29	Appreciation of the variety of approaches to sustainability issues	0.5	4.1	13.4	58.8	23.2	4.00	0.76
30	Appreciation for the need for lifelong learning in relation to sustainability issues and change	1.5	2.3	14.2	46.9	35.1	4.12	0.84

As evident in Table 4.11, the students seem to be of the opinion that the 30 hypothetical competences are part of the undergraduate engineering programme curriculum at present. This is apparent from the higher percentage of responses falling under the somewhat important and very important category. Although all competences as a whole denote high frequencies for these two categories, 28 out of the total 30 hypothetical competences listed indicate higher frequencies in the somewhat important category, rather than the very important category. The remaining two competences, 11 and 27 indicate higher frequencies in the very important category. Competence 11 denoted a frequency of 44.1% for the very important category, while 27, indicated a 44.6% frequency for the same category.

Intriguingly, the results also indicate that the somewhat important and very important frequencies for competence 26 differ by a mere 0.3%. Competence 25 recorded no responses under the very unimportant category. Furthermore, competences 6 and 14 both indicate higher frequencies for the category neither important nor unimportant in comparison to the very important category. In addition, competence 15 indicates similar frequencies for the category neither important nor unimportant and very important, with similar frequencies of 21.9% for both categories.

The mean scores of the 30 competences indicate that 7 out of the 30 competences fall under the neither important nor unimportant category, with the lowest mean score being 3.78 and the highest mean score being 3.99 for this category. These competences are competences 6, 13, 14, 15, 16, 18 and 19. The remaining 23 competences all fall under the somewhat important to very important categories. The highest mean score recorded for this category was 4.28. Two competences, namely 5 and 27 shared the same mean score of 4.28. The lowest mean score for the somewhat important to very important categories was 4.00. This mean score was recorded for two competences again, namely competences 7 and 29. Although 7 out of the 30 competences fall under the neither important nor unimportant category, the values recorded for the competences are well above the value of 3.50, indicating these competences are given importance in the undergraduate engineering programme at present.

The next section describes respondents' views on the importance of including the 30 hypothetical competences in the engineering students' learning experiences of common engineering and non-engineering module as well as university programmes.

4.6.4.1.3 Responses on the importance for engineering students to learn the 30 hypothetical sustainable development competences in common engineering and non-engineering modules and university programmes

At University X, all undergraduate engineering students have to complete an Engineering, English Language and Communication, Management, Social Science and Humanities common modules before they are allowed to graduate from the engineering programme. These common modules are usually offered to the students when they are in their first, second and third year of their studies. The content of the modules are similar, regardless of the engineering discipline the student is enrolled in. The Engineering modules are taught by the engineering academicians, while the English Language and Communication, Management, Social Science and Humanities modules are taught by the academicians from the Department of Management and Humanities.

This section highlights the results of the final year undergraduate engineering students' responses on the importance of including the 30 hypothetical competences in the common engineering and non-engineering modules offered by their respective undergraduate engineering programmes. The section also describes students' responses on the importance of the inclusion of the 30 hypothetical competences in university programmes such as research and design competitions, internship and community outreach projects the university students are involved in as part of their undergraduate studies at the university.

The results described in this section will first highlight student responses on the importance of including the 30 hypothetical competences in the Engineering modules. This will be followed by the English Language and Communication, Management, Social Science and Humanities modules and finally the university level programmes. The mean score of each item indicates the level of importance of the item. Table 4.12 refers to the results of the frequencies of responses for inclusion of the 30 hypothetical competences in Engineering Modules.

Table 4.12: Responses for inclusion of the 30 hypothetical competences in Engineering Modules

No	ITEM	VU (%)	SU (%)	N (%)	SI (%)	VI (%)	MEAN	SD
1	Understand people's relationship to nature	1.3	5.7	11.1	37.1	44.8	4.19	0.93
2	Hold appropriate understanding of how the economy, society and environment affect each other	0.5	1.5	10.6	38.9	48.5	4.33	0.77
3	Hold personal understanding of the environment which is derived from direct experience	1.0	2.1	10.3	38.9	47.7	4.30	0.82
4	Local to global understanding of how people continuously impact on the environment	0.5	1.3	8.8	34.0	55.4	4.43	0.75
5	Understand how science and technology has changed nature and people's effect to the environment	0.3	1.8	3.2	27.6	67.3	4.60	0.67
6	Understand how cultural and social values influence how resources are viewed	3.1	6.4	23.2	35.6	31.7	3.86	1.03
7	Analyze a sustainability issue creatively, critically and systemically using scientific, social science and humanities approaches	1.0	2.8	11.9	34.8	49.5	4.29	0.86
8	Able to consider present and future directions of society and environment, and personal role and contribution to the future	0.5	2.3	8.5	34.8	53.9	4.39	0.78

9	Think of a holistic approach to solving an engineering problem	0.8	2.8	5.7	28.1	62.6	4.49	0.79
10	Think of a holistic approach to solving real life complex problems	1.3	3.6	10.6	31.4	53.1	4.31	0.89
11	Able to participate in groups consisting individuals from many fields or disciplines of study to jointly evaluate causes, put forward and work out problems, and provide solutions to problems	0.5	1.5	5.9	24.7	67.3	4.57	0.72
12	Apply engineering skills to solve real life sustainability problems facing society	0.3	0.8	3.4	25.3	70.4	4.65	0.61
13	Apply language and communication skills to solve real life sustainability problems facing society	2.1	5.9	18.8	38.1	35.1	3.98	0.98
14	Apply business and management skills to solve real life sustainability problems facing society	1.5	6.2	21.1	41.8	29.4	3.91	0.94
15	Apply social science and humanities concerns to solve real life sustainability problems facing society	2.6	6.7	21.9	39.7	29.1	3.86	1.00
16	Able to critically reflect on own assumptions and assumptions of others	1.0	1.5	13.1	40.2	44.1	4.25	0.82
17	Able to critically reflect on issues on a personal and professional level	0.3	4.1	10.3	37.1	48.2	4.29	0.83
18	Able to manage and direct change at individual and social levels	2.1	3.6	12.4	41.5	40.5	4.15	0.92
19	Able to express personal responses to environmental and social issues	0.5	2.8	12.9	41.2	42.5	4.22	0.82
20	Ability to demonstrate and articulate sustainability related values such as care, respect, charity, social and economic justice, commitment, cooperation, compassion, self-determination, self-reliance, self-restraint, empathy, emotional intelligence, ethics and assertiveness	1.0	5.2	14.2	32.7	46.9	4.19	0.94
21	Play the role of responsible citizens at the local and global level for a sustainable future	0.5	3.1	9.8	33.2	53.4	4.36	0.82
22	Develop appreciation of the importance of environmental, social, political and economic contexts of engineering processes for sustainability	0.5	1.5	8.5	41.2	48.2	4.35	0.74

23	Consider implications of engineering processes in relation to the environment	0.0	1.5	6.2	29.9	62.4	4.53	0.68
24	Consider implications of engineering processes in relation to the society	0.5	0.8	4.9	34.0	59.8	4.52	0.68
25	Consider environmental issues in relation to the society	0.5	2.3	13.7	30.9	52.6	4.33	0.83
26	Appreciation of all living entities	1.3	3.6	14.7	31.2	49.2	4.23	0.92
27	Appreciation that current actions can impact on the quality of life of future generations	1.0	1.8	7.0	38.9	51.3	4.38	0.78
28	Respect and value cultural, social and economic and biodiversity	0.8	4.1	14.9	39.9	40.2	4.15	0.88
29	Appreciation of the variety of approaches to sustainability issues	0.5	2.3	11.6	39.9	45.6	4.28	0.80
30	Appreciation for the need for lifelong learning in relation to sustainability issues and change	0.8	2.6	8.5	37.1	51.0	4.35	0.80

As indicated in Table 4.12, the responses suggest that students view all competences as important to be included in the common engineering modules that have to be completed for the duration of their undergraduate engineering studies at the university. This is evident from the higher frequencies for the somewhat important and very important categories for all 30 competences. Additionally, it is apparent that the very important category frequencies for competences 5, 9, 11, 12 and 23 are all more than double the frequencies for the somewhat important category. The results also seem to indicate that the frequency of responses for the neither important nor unimportant category for competence 6 is also high, with a 23.2% frequency for this category. There was also no response for the very unimportant category for competence 23.

The mean scores obtained for all competences indicate that four competences out of the total 30 competences have mean scores lower than 4.00. These competences therefore fall under the neither important nor unimportant category. These competences are competences 6, 13, 14 and 15. Even though four of the 26 competences have a mean score of less than 4.00, these scores are above the average score of 3.50, indicating that these competences are important to be included in the Engineering modules. The remaining 26 competences fall under the somewhat important to very important category, with mean scores higher than 4.00. The highest mean recorded was for competence 12, with a mean score value of 4.65.

Table 4.13 illustrates the frequency of responses of the 388 final year undergraduate engineering students on the importance of including the 30 competences in the common English and Communication modules.

Table 4.13: Responses for inclusion of the 30 hypothetical competences in English and Communication Modules

No	ITEM	VU (%)	SU (%)	N (%)	SI (%)	VI (%)	MEAN	SD
1	Understand people's relationship to nature	3.9	8.5	23.5	35.8	28.4	3.76	1.07
2	Hold appropriate understanding of how the economy, society and environment affect each other	3.1	10.3	27.8	38.4	20.4	3.63	1.02
3	Hold personal understanding of the environment which is derived from direct experience	3.1	9.8	27.8	38.7	20.6	3.64	1.01
4	Local to global understanding of how people continuously impact on the environment	2.1	10.6	25.5	38.9	22.9	3.70	1.00
5	Understand how science and technology has changed nature and people's effect to the environment	3.1	9.0	30.2	39.7	18.0	3.61	0.98
6	Understand how cultural and social values influence how resources are viewed	1.8	9.5	28.9	36.9	22.9	3.70	0.99
7	Analyze a sustainability issue creatively, critically and systemically using scientific, social science and humanities approaches	3.4	7.5	30.9	38.7	19.6	3.64	0.99
8	Able to consider present and future directions of society and environment, and personal role and contribution to the future	1.8	8.5	26.0	40.7	22.9	3.74	0.96
9	Think of a holistic approach to solving an engineering problem	4.9	11.6	28.1	33.5	21.9	3.56	1.10
10	Think of a holistic approach to solving real life complex problems	3.6	9.0	25.8	39.4	22.2	3.68	1.03
11	Able to participate in groups consisting individuals from many fields or disciplines of study to jointly evaluate causes, put forward and work out problems, and provide solutions to problems	1.3	4.4	18.6	31.2	44.6	4.13	0.95

12	Apply engineering skills to solve real life sustainability problems facing society	5.9	9.3	30.9	33.8	20.1	3.53	1.09
13	Apply language and communication skills to solve real life sustainability problems facing society	0.3	3.6	8.2	34.0	53.9	4.38	0.81
14	Apply business and management skills to solve real life sustainability problems facing society	2.1	9.5	27.6	38.1	22.7	3.70	0.99
15	Apply social science and humanities concerns to solve real life sustainability problems facing society	2.1	9.0	26.3	39.4	23.2	3.73	0.98
16	Able to critically reflect on own assumptions and assumptions of others	1.5	4.1	19.3	45.4	29.6	3.97	0.89
17	Able to critically reflect on issues on a personal and professional level	0.3	3.9	18.8	39.9	37.1	4.10	0.85
18	Able to manage and direct change at individual and social levels	1.0	4.6	20.1	43.3	30.9	3.98	0.89
19	Able to express personal responses to environmental and social issues	1.5	6.2	22.2	40.2	29.9	3.91	0.95
20	Ability to demonstrate and articulate sustainability related values such as care, respect, charity, social and economic justice, commitment, cooperation, compassion, self-determination, self-reliance, self-restraint, empathy, emotional intelligence, ethics and assertiveness	1.5	5.2	18.8	37.4	37.1	4.03	0.95
21	Play the role of responsible citizens at the local and global level for a sustainable future	1.5	5.9	20.6	36.6	35.3	3.98	0.97
22	Develop appreciation of the importance of environmental, social, political and economic contexts of engineering processes for sustainability	1.5	7.0	22.2	38.1	31.2	3.90	0.97
23	Consider implications of engineering processes in relation to the environment	2.6	9.8	27.1	34.3	26.3	3.72	1.04
24	Consider implications of engineering processes in relation to the society	1.5	10.3	28.1	39.4	20.6	3.67	0.97
25	Consider environmental issues in relation to the society	1.3	9.3	28.9	32.5	28.1	3.77	1.00
26	Appreciation of all living entities	2.1	7.5	20.1	35.6	34.8	3.94	1.01
27	Appreciation that current actions can impact on the quality of life of future generations	1.3	6.4	20.1	43.3	28.9	3.92	0.93
28	Respect and value cultural, social and economic and biodiversity	1.3	7.2	19.8	41.0	30.7	3.93	0.95

29	Appreciation of the variety of approaches to sustainability issues	1.3	6.2	25.3	40.2	27.1	3.86	0.93
30	Appreciation for the need for lifelong learning in relation to sustainability issues and change	1.5	5.2	18.0	41.0	34.3	4.01	0.93

As shown in Table 4.13, the overall results indicate that the students' view all 30 competences as essential competences to be included in the English and Communication modules. This is evident from the higher percentage of responses projected for the somewhat important and very important categories. These results are similar to the overall results for the Engineering modules. Interestingly nevertheless, there seem to be high frequencies recorded for almost all 30 competences in the neither important nor unimportant category as well. The table shows that all competences under this category, with the exception of competences 11, 13and 20 having frequencies of 20% and higher. Competences 11, 13 and 20 on the hand, have frequencies amounting to less than 20%. The frequencies recorded for these three competences are 18.6%, 8.2% and 18.8% respectively, with competence 13 having the least frequency count of the three competences.

The mean scores of all 30 competences indicate that five out of the total 30 competences have a mean score of above 4.00. The competences with mean scores above 4.00 are competences 11 (mean = 4.13), 13 (mean = 4.38), 17 (mean = 4.10), 20 (mean = 4.03) and 30 (mean = 4.01). The remaining 25 competences have mean scores less than 4.00. Nevertheless, these scores are all above the 3.50 average value. The lowest mean score was recorded for competence 12, with a mean value of 3.53.

Table 4.14 illustrates the frequency of responses for inclusion of the 30 hypothetical competences in the common Management modules undergraduate engineering students need to complete prior to graduation from their respective engineering programmes.

Table 4.14: Responses for inclusion of the 30 hypothetical competences in Management modules

No	ITEM	VU (%)	SU (%)	N (%)	SI (%)	VI (%)	MEAN	SD
1	Understand people's relationship to nature	2.3	3.9	16.0	38.9	38.9	4.08	0.95
2	Hold appropriate understanding of how the economy, society and environment affect each other	0.8	3.9	11.3	37.1	46.9	4.26	0.86
3	Hold personal understanding of the environment which is derived from direct experience	2.6	5.9	22.4	38.9	30.2	3.88	0.99
4	Local to global understanding of how people continuously impact on the environment	1.5	7.0	16.2	40.7	34.5	4.00	0.96
5	Understand how science and technology has changed nature and people's effect to the environment	1.8	6.2	22.4	44.6	25.0	3.85	0.93
6	Understand how cultural and social values influence how resources are viewed	1.3	7.0	19.1	41.5	31.2	3.94	0.95
7	Analyze a sustainability issue creatively, critically and systemically using scientific, social science and humanities approaches	2.1	4.4	20.4	44.8	28.4	3.93	0.92
8	Able to consider present and future directions of society and environment, and personal role and contribution to the future	2.1	4.1	19.3	41.8	32.7	3.99	0.93
9	Think of a holistic approach to solving an engineering problem	2.8	8.0	22.9	36.9	29.4	3.82	1.03
10	Think of a holistic approach to solving real life complex problems	2.1	4.4	18.6	42.8	32.2	3.99	0.93
11	Able to participate in groups consisting individuals from many fields or disciplines of study to jointly evaluate causes, put forward and work out problems, and provide solutions to problems	1.0	3.1	12.9	36.1	46.9	4.25	0.87
12	Apply engineering skills to solve real life sustainability problems facing society	3.4	5.9	27.6	37.1	26.0	3.77	1.01
13	Apply language and communication skills to solve real life sustainability problems facing society	0.5	4.9	16.2	42.0	36.3	4.09	0.87
14	Apply business and management skills to solve real life sustainability problems facing society	0.5	4.4	8.2	34.3	52.6	4.34	0.85

15	Apply social science and humanities concerns to solve real life sustainability problems facing society	1.0	4.9	22.4	43.6	28.1	3.93	0.89
16	Able to critically reflect on own assumptions and assumptions of others	1.3	4.6	19.6	46.9	27.6	3.95	0.88
17	Able to critically reflect on issues on a personal and professional level	0.3	4.1	15.5	42.3	37.9	4.13	0.84
18	Able to manage and direct change at individual and social levels	0.5	3.1	14.4	45.1	36.9	4.15	0.81
19	Able to express personal responses to environmental and social issues	1.3	5.2	20.4	41.0	32.2	3.98	0.92
20	Ability to demonstrate and articulate sustainability related values such as care, respect, charity, social and economic justice, commitment, cooperation, compassion, self-determination, self-reliance, self-restraint, empathy, emotional intelligence, ethics and assertiveness	1.3	2.8	17.5	37.1	41.2	4.14	0.89
21	Play the role of responsible citizens at the local and global level for a sustainable future	1.0	3.4	19.1	36.9	39.7	4.11	0.89
22	Develop appreciation of the importance of environmental, social, political and economic contexts of engineering processes for sustainability	0.8	4.1	16.2	44.8	34.0	4.07	0.86
23	Consider implications of engineering processes in relation to the environment	1.0	5.9	25.8	34.3	33.0	3.92	0.96
24	Consider implications of engineering processes in relation to the society	1.3	7.0	17.3	44.6	29.9	3.95	0.93
25	Consider environmental issues in relation to the society	1.0	5.2	23.7	38.9	31.2	3.94	0.92
26	Appreciation of all living entities	2.1	4.4	18.6	36.3	38.7	4.05	0.97
27	Appreciation that current actions can impact on the quality of life of future generations	1.5	4.1	16.2	41.8	36.3	4.07	0.91
28	Respect and value cultural, social and economic and biodiversity	0.8	3.9	18.6	39.4	37.4	4.09	0.88
29	Appreciation of the variety of approaches to sustainability issues	0.8	3.9	24.0	37.9	33.5	3.99	0.89
30	Appreciation for the need for lifelong learning in relation to sustainability issues and change	0.8	2.8	18.8	36.9	40.7	4.14	0.87

The overall results for the Management modules indicate similarities with the overall results from the English and Communication modules. The results indicate that students' view the inclusion of the 30 hypothetical competences as important for them to learn in the common Management modules. The higher responses received for all 30 competences fall under the somewhat important and very important categories. In addition, 10 competences out the total 30 competences recorded a frequency of 20% and higher for the neither important nor unimportant category. These 10 competences are competences 3, 5, 7, 9, 12, 15, 19, 23, 25 and 29.

In terms of mean scores obtained for the 30 competences, the results indicate that the mean scores of all competences are above the average value of 3.50. This suggests that all 30 competences are important to be included in the Management modules of the undergraduate engineering programme offered by the university. The highest mean score recorded was 4.34, for competence 14. The lowest mean score was for competence 12, with a value of 3.77. In addition, 50% of the total competences recorded a mean score value of 4.00 or greater. This is in contrast with the English and Communication modules, where only 16.67% or 5 competences of the total 30 competences recorded a value of 4.00 or greater.

The following paragraphs highlight the frequency of responses for the inclusion of the 30 hypothetical competences in Social Science and Humanities modules. These values are as depicted in Table 4.15.

Table 4.15: Responses for inclusion of the 30 hypothetical competences in Social Science and Humanities modules

No	ITEM	VU (%)	SU (%)	N (%)	SI (%)	VI (%)	MEAN	SD
1	Understand people's relationship to nature	0.8	4.1	17.8	36.3	41.0	4.13	0.90
2	Hold appropriate understanding of how the economy, society and environment affect each other	0.8	3.4	17.0	41.8	37.1	4.11	0.86

3	Hold personal understanding of the environment which is derived from direct experience	1.5	4.9	20.6	42.8	30.2	3.95	0.90
4	Local to global understanding of how people continuously impact on the environment	0.5	6.4	16.2	42.0	34.8	4.04	0.90
5	Understand how science and technology has changed nature and people's effect to the environment	1.0	5.4	20.1	43.8	29.6	3.96	0.90
6	Understand how cultural and social values influence how resources are viewed	0.5	3.4	18.3	39.7	38.1	4.12	0.86
7	Analyze a sustainability issue creatively, critically and systemically using scientific, social science and humanities approaches	1.0	4.6	18.3	38.9	37.1	4.06	0.91
8	Able to consider present and future directions of society and environment, and personal role and contribution to the future	1.0	5.2	17.5	44.1	32.2	4.01	0.89
9	Think of a holistic approach to solving an engineering problem	1.8	6.7	24.7	37.6	29.1	3.86	0.98
10	Think of a holistic approach to solving real life complex problems	0.5	4.1	22.2	38.9	34.3	4.02	0.88
11	Able to participate in groups consisting individuals from many fields or disciplines of study to jointly evaluate causes, put forward and work out problems, and provide solutions to problems	0.5	5.4	14.2	35.8	44.1	4.18	0.90
12	Apply engineering skills to solve real life sustainability problems facing society	2.6	6.4	28.4	37.4	25.3	3.76	0.99
13	Apply language and communication skills to solve real life sustainability problems facing society	1.0	4.6	19.8	40.2	34.3	4.02	0.91
14	Apply business and management skills to solve real life sustainability problems facing society	1.0	5.7	20.9	37.9	34.5	3.99	0.94
15	Apply social science and humanities concerns to solve real life sustainability problems facing society	0.5	2.6	13.9	38.7	44.3	4.24	0.82
16	Able to critically reflect on own assumptions and assumptions of others	1.3	4.1	23.7	44.1	26.8	3.91	0.88
17	Able to critically reflect on issues on a personal and professional level	1.0	3.6	19.6	39.9	35.8	4.06	0.89
18	Able to manage and direct change at individual and social levels	0.5	3.4	17.3	40.2	38.7	4.13	0.85

19	Able to express personal responses to environmental and social issues	0.8	3.6	20.6	40.7	34.3	4.04	0.87
20	Ability to demonstrate and articulate sustainability related values such as care, respect, charity, social and economic justice, commitment, cooperation, compassion, self-determination, self-reliance, self-restraint, empathy, emotional intelligence, ethics and assertiveness	1.0	2.6	17.5	35.1	43.8	4.18	0.88
21	Play the role of responsible citizens at the local and global level for a sustainable future	0.3	3.1	16.2	38.7	41.8	4.19	0.83
22	Develop appreciation of the importance of environmental, social, political and economic contexts of engineering processes for sustainability	0.3	2.8	18.6	40.7	37.6	4.13	0.83
23	Consider implications of engineering processes in relation to the environment	0.5	5.7	24.0	35.8	34.0	3.97	0.92
24	Consider implications of engineering processes in relation to the society	1.3	5.7	22.7	39.7	30.7	3.93	0.93
25	Consider environmental issues in relation to the society	1.3	4.4	20.9	36.1	37.4	4.04	0.94
26	Appreciation of all living entities	1.0	4.9	16.0	34.8	43.3	4.14	0.93
27	Appreciation that current actions can impact on the quality of life of future generations	0.5	4.1	14.9	40.7	39.7	4.15	0.86
28	Respect and value cultural, social and economic and biodiversity	0.0	2.6	15.2	36.3	45.9	4.26	0.81
29	Appreciation of the variety of approaches to sustainability issues	1.0	2.1	20.9	40.2	35.8	4.08	0.86
30	Appreciation for the need for lifelong learning in relation to sustainability issues and change	0.3	3.6	18.8	37.4	39.9	4.13	0.86

Overall, the results suggest that the students view the inclusion of the 30 hypothetical competences in the common Social Science and Humanities modules as important. This is evident from the most number of responses within the somewhat important and very important categories. These results are also similar to the overall results for the Engineering, English and Communication and Management modules. Also, 12 competences out of the total 30 competences recorded frequencies of 20% and higher for the neither important nor unimportant category. These competences are competences 3, 5, 9, 10, 12, 14, 16, 19, 23, 24, 25 and 29.

The mean score of the 30 competences reveal that all competences have mean scores higher than the average value of 3.50. A total of eight competences have mean scores below 4.00, while the remaining 22 competences all have mean scores of 4.00 or higher. This indicates that all 30 competences are deemed as important to be included in the social science and humanities modules. The highest mean score was obtained for competence 26 (mean = 4.26). The lowest mean score was recorded was 3.76 for competence 12. It is interesting to note at this juncture that competence 12 also recorded the lowest mean score in two other modules, namely the English and Communication modules as well as the Management modules. However, the same item had the highest mean value in the Engineering modules.

The following paragraphs report the results of the frequency of responses of the 388 final year students on the inclusion of the 30 hypothetical competences in university programmes. Table 4.16 denotes these results.

Table 4.16: Responses for inclusion of the 30 hypothetical competences in University Programmes

No	ITEM	VU (%)	SU (%)	N (%)	SI (%)	VI (%)	MEAN	SD
1	Understand people’s relationship to nature	1.3	4.9	15.2	37.1	41.5	4.13	0.93
2	Hold appropriate understanding of how the economy, society and environment affect each other	2.1	2.1	15.7	39.2	41.0	4.15	0.90
3	Hold personal understanding of the environment which is derived from direct experience	1.8	3.9	15.2	42.3	36.9	4.09	0.91
4	Local to global understanding of how people continuously impact on the environment	1.5	4.6	15.2	38.7	39.9	4.11	0.93
5	Understand how science and technology has changed nature and people’s effect to the environment	2.3	2.8	14.9	43.0	36.9	4.09	0.91
6	Understand how cultural and social values influence how resources are viewed	2.1	3.6	18.3	42.8	33.2	4.01	0.92
7	Analyze a sustainability issue creatively, critically and systemically	2.3	5.4	14.7	41.5	36.1	4.04	0.97

	using scientific, social science and humanities approaches							
8	Able to consider present and future directions of society and environment, and personal role and contribution to the future	1.3	3.9	16.5	42.5	35.8	4.08	0.89
9	Think of a holistic approach to solving an engineering problem	1.8	4.1	15.2	38.4	40.5	4.12	0.93
10	Think of a holistic approach to solving real life complex problems	1.5	4.4	15.5	39.7	38.9	4.10	0.92
11	Able to participate in groups consisting individuals from many fields or disciplines of study to jointly evaluate causes, put forward and work out problems, and provide solutions to problems	0.8	3.6	10.8	3.8	51.0	4.31	0.86
12	Apply engineering skills to solve real life sustainability problems facing society	2.1	3.1	16.5	39.4	38.9	4.10	0.92
13	Apply language and communication skills to solve real life sustainability problems facing society	1.3	3.6	16.5	40.2	38.4	4.10	0.89
14	Apply business and management skills to solve real life sustainability problems facing society	1.0	4.6	21.1	41.8	31.4	3.98	0.90
15	Apply social science and humanities concerns to solve real life sustainability problems facing society	0.8	4.1	17.8	45.1	32.2	4.04	0.86
16	Able to critically reflect on own assumptions and assumptions of others	1.3	2.6	20.4	42.5	33.2	4.04	0.87
17	Able to critically reflect on issues on a personal and professional level	1.0	3.9	14.9	40.2	39.9	4.14	0.88
18	Able to manage and direct change at individual and social levels	0.8	1.5	17.3	40.7	39.7	4.17	0.82
19	Able to express personal responses to environmental and social issues	1.0	3.6	16.5	42.5	36.3	4.10	0.87
20	Ability to demonstrate and articulate sustainability related values such as care, respect, charity, social and economic justice, commitment, cooperation, compassion, self-determination, self-reliance, self-restraint, empathy, emotional intelligence, ethics and assertiveness	0.8	2.8	14.9	37.6	43.8	4.21	0.85
21	Play the role of responsible citizens at the local and global level for a sustainable future	0.8	3.9	14.2	37.4	43.8	4.20	0.88
22	Develop appreciation of the importance of environmental, social, political and economic contexts of engineering processes for sustainability	1.3	1.5	15.7	42.0	39.4	4.17	0.84
23	Consider implications of engineering processes in relation to the environment	1.0	3.6	13.9	36.3	45.1	4.21	0.88
24	Consider implications of engineering processes in relation to the society	1.8	3.4	13.7	41.0	40.2	4.14	0.90

25	Consider environmental issues in relation to the society	1.3	2.3	17.3	37.4	41.8	4.16	0.88
26	Appreciation of all living entities	1.0	3.4	15.5	33.5	46.6	4.21	0.90
27	Appreciation that current actions can impact on the quality of life of future generations	0.8	2.1	13.4	37.6	46.1	4.26	0.82
28	Respect and value cultural, social and economic and biodiversity	0.8	3.1	14.9	39.9	41.2	4.18	0.85
29	Appreciation of the variety of approaches to sustainability issues	1.3	3.1	15.7	40.2	39.7	4.14	0.88
30	Appreciation for the need for lifelong learning in relation to sustainability issues and change	1.3	3.1	12.1	36.9	46.6	4.24	0.88

As seen in Table 4.16, the respondents seem to view the inclusion of the 30 hypothetical competences in university programmes as important. This is evident from the most number of responses recorded for the somewhat important and very important categories. These results are once again similar to the overall results of the engineering and non-engineering modules, which all indicate the 30 hypothetical competences as important to be included in all these modules. Only two competences, competences 14 and 16 recorded frequencies of 20% and higher for the neither important nor unimportant category. The mean scores obtained suggest that the 30 competences are important to be included in university programmes. The mean scores obtained for all competences were above the average value of 3.50. The lowest mean score was recorded for competence 14. The mean score value for this particular item was 3.98. The highest mean score value was 4.26 for competence 27.

This section described the results students' responses on the importance of including the 30 hypothetical competences in the common modules as well as university programmes. Results of the relevance of the 30 competences from non-student stakeholders are described in the next section.

4.6.4.1.4 Malaysian and international ESD stakeholders' responses on the relevance of the inclusion of the 30 sustainable development competences in the undergraduate engineering and non-engineering modules and university programmes

In addition to the responses obtained from the final year undergraduate engineering students on the 30 sustainable development competences, the views of Malaysian and national ESD stakeholders were also sought for the present study. International stakeholders of ESD are in reference to the ESD experts and practitioners, while the national stakeholders refer to the academicians and engineering industry practitioners. The 30 sustainable development competences were presented to 29 non-student stakeholder respondents for their feedback. Of the 29, 18 respondents took part in this exercise, and were asked to indicate their agreement or disagreement of the 30 competences. However, for the purpose of quantitative analysis, only 17 out of the 18 responses could be included, as the remaining response was a comment on the manner in which the 30 competences could be improved. These responses were then transformed into quantitative format to gauge the percentage of the relevance of the competences. The 17 respondents were a UNESCO Chair in Social Learning and Sustainable Development, a Professor of ESD from the United Kingdom, a Social Science and Humanities Professor from Malaysia, two ESD practitioners from the United Kingdom, six academicians from the university in which the present study was conducted and six practitioners from the Malaysian engineering industry. Table 4.17 presents the results of the responses of the Malaysian and international ESD stakeholders.

Table 4.17: Results of relevance of 30 hypothetical competences from international and national ESD stakeholders

COMPETENCE		ESD EXPERTS			ESD PRACTITIONERS		ACADEMICIANS						INDUSTRY					
		EP1	EP3	EP2	EP7	EP4	A5	A9	A1	A2	A4	A3	IP4	IP1	IP6	IP3	IP2	IP5
	Understand people's relationship to nature	X		X	X		X		X	X	X	X	X			X	X	X
	TOTAL (%)	**12/17 = 70.59**																
	Hold appropriate understanding of how the economy,	X	X	X	X		X		X	X		X	X			X	X	X

	society and environment affect each other																	
	TOTAL (%)	**12/17 = 70.59**																
	Hold personal understanding of the environment which is derived from direct experience	X	X	X	X		X		X	X		X	X			X	X	X
	TOTAL (%)	**12/17 = 70.59**																
	Local to global understanding of how people continuously impact on the environment	X	X	X	X		X		X	X	X	X	X			X	X	X
	TOTAL (%)	**13/17 = 76.47**																
	Understand how science and technology has changed nature and people's effect to the environment	X	X	X	X		X		X	X	X		X			X	X	X
	TOTAL (%)	**12/17 = 70.59**																
	Understand how cultural and social values influence how resources are viewed	X	X	X	X		X		X	X	X	X				X	X	X
	TOTAL (%)	**12/17 = 70.59**																
	Analyze a sustainability issue creatively, critically and systemically using scientific, social science and humanities approaches	X	X	X	X	X	X		X			X	X	X		X	X	X
	TOTAL (%)	**13/17 = 76.47**																
	Able to consider present and future directions of society and environment,	X	X	X	X	X	X		X	X		X	X	X		X	X	X

	and personal role and contribution to the future																	
	TOTAL (%)	**14/17 = 82.35**																
	Think of a holistic approach to solving an engineering problem	X	X	X	X	X	X		X	X		X	X	X		X	X	X
	TOTAL (%)	**14/17 = 82.35**																
	Think of a holistic approach to solving real life complex problems	X	X	X	X	X	X		X	X		X		X		X	X	X
	TOTAL (%)	**13/17 = 76.47**																
	Able to participate in groups consisting individuals from many fields or disciplines of study to jointly evaluate causes, put forward and work out problems, and provide solutions to problems	X	X	X	X	X	X		X	X	X	X	X			X	X	X
	TOTAL (%)	**14/17 = 82.35**																
	Apply engineering skills to solve real life sustainability problems facing society	X		X	X		X		X	X	X	X	X	X	X	X	X	X
	TOTAL (%)	**14/17 = 82.35**																
	Apply language and communication skills to solve real life sustainability problems facing society	X	X	X	X		X		X	X	X	X	X	X	X	X	X	X
	TOTAL (%)	**15/17 = 88.24**																
	Apply business and management skills to solve real life	X		X	X		X		X	X	X	X	X	X	X	X	X	X

	sustainability problems facing society																	
	TOTAL (%)	**14/17 = 82.35**																
	Apply social science and humanities concerns to solve real life sustainability problems facing society	X	X	X	X		X		X				X			X	X	X
	TOTAL (%)	**10/17 = 58.82**																
	Able to critically reflect on own assumptions and assumptions of others	X	X	X	X		X		X	X		X	X			X	X	X
	TOTAL (%)	**12/17 = 70.59**																
	Able to critically reflect on issues on a personal and professional level	X	X	X	X	X	X		X	X		X	X			X	X	X
	TOTAL (%)	**13/17 = 76.47**																
	Able to manage and direct change at individual and social levels	X	X	X	X	X	X	X	X	X	X	X	X			X	X	X
	TOTAL (%)	**15/17 = 88.24**																
	Able to express personal responses to environmental and social issues	X	X	X	X	X	X			X		X	X			X	X	X
	TOTAL (%)	**12/17 = 70.59**																
	Ability to demonstrate and articulate sustainability related values such as care, respect, charity, social and economic justice, commitment, cooperation, compassion, self-determination, self-reliance,	X	X	X	X	X	X	X	X	X		X	X			X	X	X

	self-restraint, empathy, emotional intelligence, ethics and assertiveness																	
	TOTAL (%)	**14/17 = 82.35**																
	Play the role of responsible citizens at the local and global level for a sustainable future	X	X	X	X	X	X	X		X	X	X				X	X	X
	TOTAL (%)	**13/17 = 76.47**																
	Develop appreciation of the importance of environmental, social, political and economic contexts of engineering processes for sustainability	X	X	X	X	X	X	X		X		X	X	X		X	X	X
	TOTAL (%)	**14/17 = 82.35**																
	Consider implications of engineering processes in relation to the environment	X	X	X	X	X	X	X		X		X	X			X	X	X
	TOTAL (%)	**13/17 = 76.47**																
	Consider implications of engineering processes in relation to the society	X	X	X	X	X	X	X		X		X	X			X	X	X
	TOTAL (%)	**13/17 = 76.47**																
	Consider environmental issues in relation to the society	X	X	X	X	X	X	X		X	X	X	X			X	X	X
	TOTAL (%)	**14/17 = 82.35**																
	Appreciation of all living entities	X	X	X	X	X	X	X		X		X	X			X	X	X
	TOTAL (%)	**13/17 = 76.47**																
	Appreciation that current actions can impact on the quality of life of future generations	X	X	X	X	X	X	X		X	X	X	X			X	X	X

	TOTAL (%)	**14/17 = 82.35**																
	Respect and value cultural, social and economic and biodiversity	X	X	X	X	X	X	X		X	X	X	X	X		X	X	X
	TOTAL (%)	**15/17 = 88.24**																
	Appreciation of the variety of approaches to sustainability issues	X	X	X	X	X	X	X		X	X	X	X	X		X	X	X
	TOTAL (%)	**15/17 = 88.24**																
	Appreciation for the need for lifelong learning in relation to sustainability issues and change	X	X	X	X	X	X	X		X			X			X	X	X
	TOTAL (%)	**12/17 = 70.59**																

As illustrated in Table 4.17, non-student stakeholders found all 30 competences to be of relevance. Three competences recorded the highest percentage of relevance of 88.24%. These were *able to manage and direct change at individual and social levels, respect and value cultural, social and economic and biodiversity* and *appreciation of the variety of approaches to sustainability issues* and *apply language and communication skills to solve real life sustainability problems facing society*. The competence *able to critically reflect on own assumptions and assumptions of others* recorded the lowest percentage of relevance, with a value of 58.82%.

The section that follows describes the results of the analysis conducted in line with the suggestions provided by the ESD experts to improve the manner in which the 30 competences could be categorized.

4.6.4.1.5 Grouping of competences through exploratory factor analysis

As highlighted earlier in this chapter, ESD experts suggested several modifications to the 30 competences. Modifications suggested include the reduction of the number of competences, as well as the re-categorization of the competences. In line with these suggestions, a factor analysis was conducted to look into possible grouping.

State Hair et al (1998), factor analysis can be employed to 'examine the underlying patterns or relationships for a large number of competences and to determine whether the information can be condensed or summarized in a smaller set of factors or components' (p. 88). The two most common forms of factor analysis are the exploratory and confirmatory forms. Exploratory factor analysis is used when a researcher seeks to explore structures within a set of items as well as to reduce data. In using this method, the researcher does not set 'any a priori constraints on the estimation of components or the number of components to be extracted' (Hair et al, 1998: p. 91). Confirmatory factor analysis is used when a researcher aims to test a hypothesis on 'which items should be grouped together on a factor or the precise number of factors' (Hair et al, 1998: p. 91).

In line with the suggestion to reduce the number of competences developed, the exploratory factor analysis technique best suited the goals of the present study. The exploratory factor analysis technique enabled me not only to 'retain the nature and character of the original item' (Hair et al, 1998: p. 95) but also to reduce the number of items, which could then be employed for further analysis. The model used to obtain factor solutions in the present study was the principal component analysis model. State Hair et al (1998), the principal component analysis model is more appropriate than the common factor analysis model when the main concern is about determining the least number of factors that would be needed 'to account for the maximum portion of the variance represented in the original set of items' (p.102). In accordance with these characteristics, the principal component analysis was determined as the most appropriate factor model to utilize for the reduction of items and categorization of the 30 competences.

Before the discussion of the principal component analysis, I would first like to justify and clarify my stand on the need for the use of this technique in the present study. While it can be argued that the approach to narrowing down the items to smaller units may project comprehensiveness, there is nevertheless a risk of it being rather mechanistic and reductionist. Nevertheless, it is my believe that such an approach is a necessary starting point in assisting academicians and universities to determine the manner in which ESD can be integrated and assessed within academic learning outcomes and university programmes. Such categorization is extremely useful in an outcome based engineering education platform, which has a primary focus on empirical measurement of student performance, more commonly known as outcomes. With the growing tendency for curriculum audits to be conducted during a university's sustainability audit, the presence of an ESD learning outcomes list and framework would thus be useful to audit the curriculum for elements of sustainable development.

In the present study, the principal component analysis model was used as a basis to explore the manner in which the 30 items could be reduced and further categorized as competences. The following sub-sections from the survey were identified for the principal component analysis: Sub-section (a), Sub-section (d) Engineering, Sub-section (d) English language and Communication, Sub-section (d) Management and Business, Sub-section (d) Social Science and Humanities Sub-section (d) University programmes. These sub-sections were identified for the principal component analysis procedure as the derived factors were to be used in the development of the framework.

4.6.4.1.5.1 Principal component analysis requirements

Prior to conducting the principal component analysis on the identified data, several criteria must first be met in order for the analysis to be conducted appropriately. This section thus highlights the requirements that were taken into consideration prior to conducting the analysis for the present study. The decisions made in relation to these requirements were guided by Hair et al (2009). The principal component analysis is a reiterative process. Hence, if the data is found to flaunt any of the requirements from steps c – i listed below, the principal component analysis process is repeated until all requirements are fulfilled. These requirements are as listed below:

a. The sample size is to be greater than 100
b. The case to item ratio is to be 5:1 or larger

c. The correlation matrix for the items must contain two or more correlations of 0.30 or greater
d. Items with measures of sampling adequacy less than 0.50 are to be removed
e. The overall measure of sampling adequacy is to be 0.50 or higher
f. The probability associated with the Bartlett test of sphericity is to be less than the level of significance, i.e. <0.001
g. The derived components should have a communality of 0.50 or greater
h. No items should have complex structures, i.e. have loadings of 0.40 or higher for more than one component
i. No component should have only a single item in it

SPSS version 19 was used for the process of analysis. The extraction method used was the principal component analysis method, while the rotation method used was the varimax method. All 388 responses were used for the purpose of analysis. This number of responses is greater than the sample size required, as stipulated in the sample size requirement. The case to item ratio of 12.9: 1 is also in line with the requirement of the principal component analysis, which requires a case to item ratio of at least 5:1 or larger.

4.6.4.1.5.2 Results of principal component analysis of abilities needed to become sustainability competent engineers

This section describes the results of the principal component analysis conducted to explore the components derived from the 30 competences that studied the abilities needed by undergraduate engineering students to become sustainability competent engineers. A total of 11 iterations were conducted to derive the final components for abilities needed to become sustainability competent engineers. The principal component analysis derived 3 components, which explain 63.28% of the total variance. The Bartlett's test of sphericity indicated a value of 0.000, which is less than the 0.001 significance level. This indicates that there were significant correlations between the items in the correlation matrix. Additionally, the measure of sampling adequacy value was 0.892. According to Hair et al (1998), a measure of sampling adequacy value of '0.80 and above is meritorious, 0.70 or above is middling, 0.60 or above is mediocre, 0.50 or above is miserable, and 0.50 or below is unacceptable' (p. 99). As the measure of sampling adequacy 'quantify the degree of intercorelations among the items' (Hair et al, 1998. p. 99), the closer the value is to 1 (from a range of 0 to 1), 'each item is perfectly predicted without error by the other items' (Hair et al, 1998. p. 99). Given these criteria, the 0.892 value obtained in this study is meritorious. The components derived are as depicted in Table 4.18.

Table 4.18: Components derived from principal component analysis of abilities needed to become sustainability competent engineers (n=388)

Component	Competences	Loading	Communality	Alpha value
1	Understand people's relationship to nature (Item 1)	0.67	0.54	0.85 (7 items)
	Hold appropriate understanding of how the economy, society and environment affect each other (Item 2)	0.61	0.53	
	Local to global understanding of how people continuously impact on the environment (Item 4)	0.78	0.66	
	Understand how science and technology has changed nature and people's effect to the environment (Item 5)	0.78	0.63	
	Able to express personal responses to environmental and social issues (Item 19)	0.56	0.51	
	Ability to demonstrate and articulate sustainability related values such as care, respect, charity, social and economic justice, commitment, cooperation, compassion, self-determination, self-reliance, self-restraint, empathy, emotional intelligence, ethics and assertiveness (Item 20)	0.62	0.50	
	Play the role of responsible citizens at the local and global level for a sustainable future	0.63	0.55	

	(Item 21)			
2	Apply language and communication skills to solve real life sustainability problems facing society (Item 13)	0.80	0.70	0.76 (3 items)
	Apply business and management skills to solve real life sustainability problems facing society (Item 14)	0.83	0.74	
	Apply social science and humanities concerns to solve real life sustainability problems facing society (Item 15)	0.67	0.59	
3	Think of a holistic approach to solving an engineering problem (Item 9)	0.88	0.84	0.83 (2 items)
	Think of a holistic approach to solving real life complex problems (Item 10)	0.84	0.82	

Table 4.18 illustrates the items, the loading, communality and Cronbach's alpha reliability values for the three components derived from the principal component analysis. States Hair et al (1998), 'factor loadings greater than 0.30 are considered to meet the minimal level, while loadings of 0.40 are considered more important. It becomes practically significant if the loading is 0.50 or greater (p.111). The factor loading presented in Table 4.18 all denote a loading of 0.50 or greater, indicating significance. The components derived from the principal component analysis have been labelled as competences, in line with the modifications suggested by the ESD experts:

Component 1: Competences for comprehension, expression and demonstration of sustainable development consciousness

Component 2: Competences for community based problem resolution

Component 3: Competences for holistic problem solving

According to Hair et al (1998), the generally agreed upon alpha lower limit for Cronbach's alpha is 0.70. However, this value may decrease to 0.60 in exploratory research. The internal consistency for each of the newly developed scales was examined using Cronbach's alpha. Components one, two and three had alpha values of 0.85, 0.76 and 0.83 respectively. Given the high alpha values obtained, the scales are highly reliable, given the exploratory nature of the present study. Composite scores were computed for each of the components, based on the mean score of the items. These values are as depicted in Table 4.19.

Table 4.19: Composite scores for components of abilities needed to become sustainability competent engineers (n=388)

Component	No of items	Mean	Standard Deviation
1	7	4.33	0.56
2	3	4.14	0.67
3	2	4.30	0.77

The mean score and standard deviation for component 1 were 4.33 and 0.56 respectively. The mean score for component 2 was 4.14 while the standard deviation was 0.67. The last component had a mean score of 4.30 and a standard deviation value of 0.77. The high mean scores indicate the importance of the inclusion of these components within the undergraduate engineering education programme educational outcomes.

4.6.4.1.5.3 Principal component analysis of the inclusion of the 30 competences in Engineering Modules

This section explains the results of the principal component analysis conducted to explore the components derived from the 30 competences that are important for engineering students to gain knowledge on, and be included as learning outcomes of the Engineering modules in their undergraduate engineering programme. A total of eight iterations were conducted to derive the final components. The principal component analysis derived 4 components, which explain 61.43% of the total variance. The Bartlett’s test of sphericity indicated a value of 0.000, which is less than the 0.001 significance level. This indicates that there were significant correlations between the items in the correlation matrix. The measure of sampling adequacy value was 0.935, which indicates it is meritorious. The components derived are as depicted in Table 4.20.

Table 4.20: Components derived from principal component analysis of the inclusion of the 30 competences in Engineering Modules (n=388)

Component	Competences	Loading	Communality	Alpha value
1	Develop appreciation of the importance of environmental, social, political and economic contexts of engineering processes for sustainability (Item 22)	0.64	0.55	0.85 (6 items)
	Consider implications of engineering processes in relation to the society (Item 24)	0.76	0.67	
	Consider environmental issues in relation to the society (Item 25)	0.71	0.66	
	Appreciation of all living entities (Item 26)	0.63	0.58	
	Appreciation that current actions can impact on the quality of life of future generations (Item 27)	0.67	0.60	
	Appreciation of the variety of approaches to sustainability issues (Item 29)	0.64	0.52	
2	Understand how cultural and social values influence how resources are viewed (Item 6)	0.69	0.62	0.85 (5 items)
	Apply language and communication skills to solve real life sustainability problems facing society (Item 13)	0.70	0.58	
	Apply business and management skills to solve real life sustainability problems facing society (Item 14)	0.74	0.64	
	Apply social science and humanities concerns to solve real life sustainability problems facing society (Item 15)	0.74	0.70	
	Able to manage and direct change at individual and social levels (Item 18)	0.67	0.60	
	Understand people's relationship to nature (Item 1)	0.61	0.51	0.83

3	Hold appropriate understanding of how the economy, society and environment affect each other (Item 2)	0.64	0.53	(6 items)
	Hold personal understanding of the environment which is derived from direct experience (Item 3)	0.72	0.63	
	Local to global understanding of how people continuously impact on the environment (item 4)	0.71	0.60	
	Understand how science and technology has changed nature and people's effect to the environment (Item 5)	0.72	0.61	
	Analyze a sustainability issue creatively, critically and systemically using scientific, social science and humanities approaches (Item 7)	0.55	0.52	
4	Think of a holistic approach to solving an engineering problem (Item (9)	0.87	0.83	0.75 (2 items)
	Think of a holistic approach to solving real life complex problems (Item 10)	0.76	0.75	

Table 4.20 illustrates the items, the loading, communality and Cronbach's alpha reliability values for the four components derived from the principal component analysis. The factor loading presented in the table denote a loading of 0.50 or greater, indicating significance. The components derived from the principal component analysis have been labelled as follows:

Component 1: Competences for appreciation of the need for sustainability consciousness within engineering practices affecting society

Component 2: Competences for the observation of sustainable development at individual and social levels

Component 3: Competences for comprehension, expression and demonstration of sustainable development consciousness

Component 4: Competences for holistic approach to problem resolution

Components one, two, three and four had alpha values of 0.85, 0.85, 0.83 and 0.75 respectively. Given the high alpha values obtained, the scales are highly reliable, for a newly developed scale. Composite scores were computed for each of the components, based on the mean score of the items. These values are as stated in Table 4.21.

Table 4.21: Composite scores for components of the inclusion of the 30 competences in Engineering Modules (n=388)

Component	No of items	Mean	Standard Deviation
1	6	4.35	0.60
2	5	3.95	0.77
3	6	4.36	0.59
4	2	4.40	0.76

The mean score and standard deviation for component 1 were 4.35 and 0.60 respectively. The mean score for component 2 was 3.95 while the standard deviation was 0.77. The third component had a mean score of 4.36 and a standard deviation of 0.59. The final component had a mean score and standard deviation value of 4.40 and 0.76 respectively. The high mean scores indicate the importance of the inclusion of these components within the undergraduate engineering education learning outcomes of the Engineering modules.

4.6.4.1.5.4 Principal component analysis of the inclusion of the 30 competences in English Language and Communication modules

This section describes the results of the principal component analysis conducted to explore competences that are important for engineering students to gain knowledge on, and be included as learning outcomes of the English Language and Communication modules. A total of five iterations were conducted to derive the final components. The principal component analysis derived three components, which explain 60.22% of the total variance. The Bartlett's test of sphericity indicated a value of 0.000, which is less than the 0.001 significance level. This indicates that there were significant correlations between the items in the correlation matrix. The measure of sampling adequacy value was 0.959, which indicates it is meritorious. The three components derived are as depicted in Table 4.22.

Table 4.22: Components derived from principal component analysis of the inclusion of the 30 competences in English Language and Communication modules (n=388)

Component	Competences	Loading	Communality	Alpha value
1	Understand people's relationship to nature (Item 1)	0.63	0.54	0.92 (10 items)
	Hold appropriate understanding of how the economy, society and environment affect each other (Item 2)	0.72	0.62	
	Hold personal understanding of the environment which is derived from direct experience (Item 3)	0.71	0.64	
	Local to global understanding of how people continuously impact on the environment (Item 4)	0.67	0.61	
	Understand how science and technology has changed nature and people's effect to the environment (Item 5)	0.71	0.60	
	Analyze a sustainability issue creatively, critically and systemically using scientific, social science and humanities approaches (Item 7)	0.70	0.63	
	Able to consider present and future directions of society and environment, and personal role and contribution to the future (Item 8)	0.69	0.58	
	Think of a holistic approach to solving an engineering problem (Item 9)	0.73	0.61	
	Think of a holistic approach to solving real life complex problems (Item 10)	0.62	0.52	
	Apply engineering skills to solve real life sustainability problems facing society (Item 12)	0.66	0.55	
2	Ability to demonstrate and articulate sustainability related values such as care, respect, charity, social and economic justice, commitment, cooperation, compassion, self-determination, self-reliance, self-restraint, empathy, emotional intelligence, ethics and assertiveness (Item 20)	0.64	0.56	0.92 (9 items)

	Play the role of responsible citizens at the local and global level for a sustainable future (item 21)	0.72	0.64	
	Develop appreciation of the importance of environmental, social, political and economic contexts of engineering processes for sustainability (item 22)	0.63	0.58	
	Consider environmental issues in relation to the society (Item 25)	0.69	0.65	
	Appreciation of all living entities (Item 26)	0.70	0.59	
	Appreciation that current actions can impact on the quality of life of future generations (Item 27)	0.72	0.63	
	Respect and value cultural, social and economic and biodiversity (Item 28)	0.72	0.63	
	Appreciation of the variety of approaches to sustainability issues (item 29)	0.74	0.64	
	Appreciation for the need for lifelong learning in relation to sustainability issues and change (Item 30)	0.71	0.55	
3	Apply language and communication skills to solve real life sustainability problems facing society (Item 13)	0.73	0.60	0.73 (3 items)
	Able to critically reflect on issues on a personal and professional level (Item 17)	0.72	0.69	
	Able to manage and direct change at individual and social levels (Item 18)	0.63	0.59	

Table 4.22 illustrates the items, the loading, communality and Cronbach's alpha reliability values for the three components derived from the principal component analysis. The factor loading presented in the table denote a loading of 0.50 or greater, indicating significance. The components derived from the principal component analysis have been labelled as follows:

Component 1: Competences for the comprehension of sustainable development

Component 2: Competences for the expression and demonstration of sustainable development consciousness

Component 3: Competences for implementation of sustainable development conventions within the community at individual, societal and professional levels

Components one, two and three had alpha values of 0.92, 0.92 and 0.73 respectively. Given the high alpha values obtained, the scales are highly reliable, for a newly developed scale. Composite scores were computed for each of the components, based on the mean score of the items, and are as stated in Table 4.23.

Table 4.23: Composite scores for components of the inclusion of the 30 competences in English Language and Communication Modules (n=388)

Component	No of items	Mean	Standard Deviation
1	10	3.65	0.77
2	9	3.93	0.75
3	3	4.15	0.68

The mean score and standard deviation for component 1 were 3.65 and 0.77 respectively. The mean score for component 2 was 3.93 while the value of the standard deviation was 0.75. The third component had a mean score of 4.15 and a standard deviation of 0.68. The high mean scores indicate the importance of the inclusion of these components within the undergraduate engineering education learning outcomes of the English Language and Communication modules.

4.6.4.1.5.5 Principal component analysis of the inclusion of the 30 competences in Management modules

This section describes the results of the principal component analysis conducted to explore the competences that are important for engineering students to gain knowledge on, and be included as learning outcomes of the Management modules offered in their undergraduate engineering programme. A total of 15 iterations were conducted to derive the final components. The principal component analysis derived two components, which explain 59.55% of the total variance. The Bartlett's test of sphericity indicated a value of 0.000, which is less than the 0.001 significance level. This indicates that there were significant correlations between the items in the correlation matrix. The measure of sampling adequacy value was 0.924, which indicates it is meritorious. The two components derived are as depicted in Table 4.24.

Table 4.24: Components derived from principal component analysis of the inclusion of the 30 competences in Management modules (n=388)

Component	Competences	Loading	Communality	Alpha value
1	Ability to demonstrate and articulate sustainability related values such as care, respect, charity, social and economic justice, commitment, cooperation, compassion, self-determination, self-reliance, self-restraint, empathy, emotional intelligence, ethics and assertiveness (Item 20)	0.70	0.56	0.89 (8 items)
	Play the role of responsible citizens at the local and global level for a sustainable future (Item 21)	0.75	0.64	
	Develop appreciation of the importance of environmental, social, political and economic contexts of engineering processes for sustainability (Item 22)	0.67	0.55	
	Appreciation of all living entities (Item 26)	0.66	0.56	
	Appreciation that current actions can impact on the quality of life of future generations (Item 27)	0.71	0.58	
	Respect and value cultural, social and economic and biodiversity (Item 28)	0.66	0.53	
	Appreciation of the variety of approaches to sustainability issues (Item 29)	0.75	0.65	
	Appreciation for the need for lifelong learning in relation to sustainability issues and change (Item 30)	0.72	0.55	

2	Understand people's relationship to nature (Item 1)	0.81	0.70	0.85 (5 items)
	Hold appropriate understanding of how the economy, society and environment affect each other (item 2)	0.72	0.58	
	Hold personal understanding of the environment which is derived from direct experience (Item 3)	0.74	0.64	
	Local to global understanding of how people continuously impact on the environment (Item 4)	0.74	0.71	
	Understand how science and technology has changed nature and people's effect to the environment (Item 5)	0.64	0.51	

Table 4.24 illustrates the items, the loading, communality and Cronbach's alpha reliability values for the two components derived from the principal component analysis. The factor loadings all denote a loading of 0.50 or greater, indicating significance. The two components derived from the principal component analysis have been labelled as follows:

Component 1: Competences for the expression and demonstration of sustainable development consciousness

Component 2: Competences for the comprehension of sustainable development

Components one and two had alpha values of 0.89 and 0.85 respectively. Given the high alpha values obtained, the scales are highly reliable, for a newly developed scale. Composite scores were computed for each of the components, based on the mean score of the items, and are as stated in Table 4.25.

Table 4.25: Composite scores for components of the inclusion of the 30 competences in Management modules (n=388)

Component	No of items	Mean	Standard Deviation
1	8	4.08	0.68
2	5	4.01	0.74

The mean score and standard deviation for component 1 were 4.08 and 0.68 respectively. The mean score for component 2 was 4.01, while the standard deviation value was 0.74. The high mean scores indicate the importance of the inclusion of these components within the undergraduate engineering education learning outcomes of the Management modules.

4.6.4.1.5.6 Principal component analysis of the inclusion of the 30 competences in Social Science and Humanities modules

This section describes the results of the principal component analysis conducted to explore competences that are important for engineering students to gain knowledge on, and be included as learning outcomes of the Social Science and Humanities modules. A total of 15 iterations were conducted to derive the final components. The principal component analysis derived two components, which explain 59.41% of the total variance. The Bartlett's test of sphericity indicated a value of 0.000, which is less than the 0.001 significance level. This indicates that there were significant correlations between the items in the correlation matrix. The measure of sampling adequacy value was 0.934, which indicates it is meritorious. The two components derived are as depicted in Table 4.26.

Table 4.26: Components derived from principal component analysis of the inclusion of the 30 competences in Social Science and Humanities modules (n=388)

Component	Competences	Loading	Communality	Alpha value
1	Understand people's relationship to nature (Item 1)	0.74	0.57	0.89 (8 items)
	Hold appropriate understanding of how the economy, society and environment affect each other (Item 2)	0.73	0.56	
	Hold personal understanding of the environment which is derived from direct experience (Item 3)	0.70	0.56	
	Local to global understanding of how people continuously impact on the environment (Item 4)	0.74	0.63	
	Understand how science and technology has changed nature and people's effect to the environment (Item 5)	0.65	0.50	
	Understand how cultural and social values influence how resources are viewed (Item 6)	0.67	0.54	

	Analyze a sustainability issue creatively, critically and systemically using scientific, social science and humanities approaches (Item 7)	0.71	0.57	
	Able to consider present and future directions of society and environment, and personal role and contribution to the future (Item 8)	0.64	0.57	
2	Appreciation of all living entities (Item 26)	0.67	0.56	0.86 (5 items)
	Appreciation that current actions can impact on the quality of life of future generations (Item 27)	0.72	0.64	
	Respect and value cultural, social and economic and biodiversity (Item 28)	0.73	0.63	
	Appreciation of the variety of approaches to sustainability issues (Item 29)	0.80	0.71	
	Appreciation for the need for lifelong learning in relation to sustainability issues and change (Item 30)	0.81	0.67	

Table 4.26 illustrates the items, the loading, communality and Cronbach's alpha reliability values for the two components derived from the principal component analysis. The factor loading presented in the table denote a loading of 0.50 or greater, indicating significance. The two components derived from the principal component analysis have been labelled as follows:

Component 1: Competences for the comprehension of sustainable development

Component 2: Competences for the expression and demonstration of sustainable development consciousness

Components one and two had alpha values of 0.89 and 0.86 respectively. Given the high alpha values obtained, the scales are highly reliable, for a newly developed scale. Composite scores were computed for each of the components, based on the mean score of the items, and are as stated in Table 4.27.

Table 4.27: Composite scores for components of the inclusion of the 30 competences in Social Science and Humanities Modules (n=388)

Component	No of items	Mean	Standard Deviation
1	8	4.05	0.67
2	5	4.15	0.69

The mean score and standard deviation for component 1 were 4.05 and 0.67 respectively. The mean score for component 2 was 4.15 while the value of the standard deviation was 0.69. The high mean scores indicate the importance of the inclusion of these components within the undergraduate engineering education learning outcomes of the Social Science and Humanities modules.

4.6.4.1.5.7 Principal component analysis of the inclusion of the 30 competences in University Programmes

This section describes the results of the principal component analysis conducted to explore competences that are important for engineering students to gain knowledge on, and be included as learning outcomes of University programmes such as such as research and design competitions, internship and community outreach projects the undergraduate students are involved in, as part of their undergraduate learning experience at the university. One iteration was conducted to derive the final components. The principal component analysis derived three components, which explain 63.57% of the total variance. The Bartlett’s test of sphericity indicated a value of 0.000, which is less than the 0.001 significance level. This indicates that there were significant correlations between the items in the correlation matrix. The measure of sampling adequacy value was 0.958, which indicates it is meritorious. The components derived are as described in Table 4.28.

Table 4.28: Components derived from principal component analysis of the inclusion of the 30 competences in University Programmes (n=388)

Component	Competences	Loading	Communality	Alpha value
1	Able to manage and direct change at individual and social levels (Item 18)	0.51	0.51	0.92 (9 items)
	Develop appreciation of the importance of environmental, social, political and economic contexts of engineering processes for sustainability (Item 22)	0.59	0.58	
	Consider implications of engineering processes in relation to the environment (Item 23)	0.64	0.61	
	Consider environmental issues in relation to the society (Item 25)	0.69	0.64	
	Appreciation of all living entities (Item 26)	0.74	0.64	
	Appreciation that current actions can impact on the quality of life of future generations (Item 27)	0.77	0.70	
	Respect and value cultural, social and economic and biodiversity (Item 28)	0.76	0.70	
	Appreciation of the variety of approaches to sustainability issues (Item 29)	0.69	0.64	
	Appreciation for the need for lifelong learning in relation to sustainability issues and change (Item 30)	0.70	0.58	
2	Understand people's relationship to nature (Item 1)	0.73	0.63	0.91 (8 items)
	Hold appropriate understanding of how the economy, society and environment affect each other (Item 2)	0.76	0.71	
	Hold personal understanding of the environment which is derived from direct experience (Item 3)	0.65	0.60	
	Local to global understanding of how people continuously impact on the environment (Item 4)	0.63	0.63	
	Understand how science and technology has changed nature	0.65	0.62	

	and people's effect to the environment (Item 5)			
	Understand how cultural and social values influence how resources are viewed (Item 6)	0.66	0.65	
	Analyze a sustainability issue creatively, critically and systemically using scientific, social science and humanities approaches (Item 7)	0.66	0.63	
	Able to consider present and future directions of society and environment, and personal role and contribution to the future (Item 8)	0.63	0.61	
3	Think of a holistic approach to solving an engineering problem (Item 9)	0.80	0.75	0.87 (5 items)
	Think of a holistic approach to solving real life complex problems (Item 10)	0.79	0.74	
	Able to participate in groups consisting individuals from many fields or disciplines of study to jointly evaluate causes, put forward and work out problems, and provide solutions to problems (Item 11)	0.67	0.63	
	Apply engineering skills to solve real life sustainability problems facing society (Item 12)	0.69	0.64	
	Apply language and communication skills to solve real life sustainability problems facing society (Item 13)	0.53	0.57	

Table 4.28 illustrates the items, the loading, communality and Cronbach's alpha reliability values for the three components derived from the principal component analysis. The factor loading presented denote a loading of 0.50 or greater, indicating significance. The three components derived from the principal component analysis have been labelled as follows:

Component 1: Competences for the expression and demonstration of sustainable development consciousness at individual, professional and societal levels

Component 2: Competences for local and global comprehension of sustainable development using empirical and non-empirical measures

Component 3: Competences for holistic problem resolution

Components one, two and three had alpha values of 0.92, 0.91 and 0.87 respectively. Given the high alpha values obtained, the scales are highly reliable, for a newly developed scale. Composite scores were also computed for each of the components, based on the mean score of the items, and are as stated in Table 4.29.

Table 4.29: Composite scores for components of the inclusion of the 30 competences in University Programmes (n=388)

Component	No of items	Mean	Standard Deviation
1	9	4.19	0.67
2	8	4.09	0.73
3	5	4.15	0.74

The mean score and standard deviation for component 1 were 4.19 and 0.67 respectively. The mean score for component 2 was 4.09 while the value of the standard deviation was 0.73. The mean score and standard deviation for component 3 were 4.15 and 0.74 respectively. The high mean scores indicate the importance of the inclusion of these components within the outcomes of University Programmes.

This section described the results of the factor analysis conducted to group the 30 competences in lieu of the suggestions for improvement provided by the ESD experts. The section that follows presents the final year undergraduate engineering students’ attitudes and preferences towards the teaching of sustainable development in the undergraduate engineering programme.

4.6.4.1.6 Results for final year undergraduate engineering students' attitudes and preferences towards the teaching of sustainable development in the undergraduate engineering programme

This section will describe results from Question (f) of Section C of the survey. The purpose of this question was to determine the students' preferences towards the teaching of sustainable development in the undergraduate engineering programme at the university. There were a total of 9 statements in this question. A five point Likert scale was used to obtain respondents' attitudes and preferences. The scale used was an agreement scale. The five points of the scale denoted 1, for strongly disagree, 2 for disagree, 3 for undecided, 4 for agree and 5 for strongly agree. The mean score of each item indicates the level of agreement for the items. The summary of responses for question (f) is as illustrated in Table 4.30.

Table 4.30: Approach to teaching sustainable development in the undergraduate engineering programme

ITEM	SD (%)	D (%)	U (%)	A (%)	SA (%)	MEAN	SD
As a separate engineering course on its own	8.5	21.1	18.8	32.7	18.8	3.32	1.24
As a separate non-engineering course on its own	7.7	20.1	22.4	35.1	14.7	3.29	1.17
Through all engineering courses only	7.2	23.5	20.9	32.2	16.2	3.27	1.19
Through all non-engineering (language and communication, business/management and social science/humanities) courses only	6.7	21.4	23.7	32.7	15.5	3.29	1.16
Within all engineering and non-engineering courses	1.5	4.4	16.5	41.2	36.3	4.06	0.92
The engineering lecturers should teach sustainability related content	0.5	1.3	8.0	45.4	44.8	4.34	0.72
The language/communication lecturers should teach sustainability related content	1.5	6.4	14.4	42.8	34.8	4.03	0.94
The management lecturers should teach sustainability related content	1.3	2.8	11.3	48.2	36.3	4.15	0.83

The social science/humanities lecturers should teach sustainability related content	1.3	3.1	11.9	44.1	39.7	4.18	0.85

The first item sought to determine respondents' preferences on whether sustainable development input should be taught as a separate engineering module on its own. 32.7% and 18.8% of the responses indicate agreement and strong agreement for this option, while 18.8% accounted for undecided responses. In addition, 21.1% and 8.5% of the respondents were in disagreement and strong disagreement of this option. The mean score of 3.32 recorded for this item however indicates that respondents were not in agreement with the teaching sustainable development in the undergraduate engineering programme as a separate engineering course on its own.

The second item focused on seeking respondents' preferences for sustainable development input to be taught as a separate non-engineering module on its own. While 7.7% and 20.1% of the responses indicated strong disagreement and disagreement to this option respectively, 22.4% were undecided. 35.1% and 14.7% of the responses were for the agree and strongly agree category respectively. These results suggest that respondents' preferred sustainable development input to be taught as two separate modules in the undergraduate engineering programme at the university. Once again, the lower than average mean score of 3.29 indicates that it should not be taught as a separate non-engineering course on its own.

Item three sought to determine final year undergraduate engineering students' responses to whether sustainable development input should be provided through all engineering modules only. These include all courses, be it a common module, or otherwise. The results indicate that 32.2% and 16.2% of the respondents agreed and strongly agreed to such form of input respectively. However, 20.9% were undecided, while 7.2% strongly disagreed and the 23.5% of them disagreed to this option. The mean score of 3.27 obtained for this item indicates that respondents were in disagreement of this approach.

Item four aimed to determine respondents' preferences to the teaching of sustainable development input through all non-engineering modules, i.e. language and communication, business/management and social science/humanities modules. These included all common modules and elective modules. The results indicate that 23.7% and 32.7% of the responses were recorded for the agree and strongly agree categories respectively. 6.7% and 21.4% of the responses were for the strongly disagree and disagree category, while 23.7% of the responses were for the undecided category. The 3.29 mean score value obtained once again indicated disagreement in using this approach to the teaching of sustainable development in the undergraduate engineering programme.

The fifth item was on providing sustainable development input through all engineering and non-engineering modules, irrespective of if the module was a common module or otherwise. The results indicate that 41.2% and 36.3% of responses were recorded for the agree and strongly agree categories. 16.5% were undecided, while 1.5% and 4.4% indicated strong disagreement and disagreement respectively. The 4.06 mean score value obtained indicates agreement to this approach.

The final four items sought to understand the 388 respondents' preferences on the lecturers who should teach sustainability related content to the undergraduate engineering students. Respondents were asked to indicate the extent to which the Engineering, English Language and Communication, Management and Social Sciences and Humanities should teach sustainability content. In the case of Engineering lecturers, 0.5% of the responses indicated strong disagreement, 1.3% indicated disagreement while 8% denoted undecided responses. Higher percentage of the responses were recorded for the agree and strongly agree categories, with 45.4% and 44.8% of responses accordingly. In relation to the English Language and Communication lecturers, a combined response of 77.6% was recorded for the agree and strongly agree category. 14.4% of the responses were undecided, while 1.5% and 6.4% of the responses were in strong disagreement and disagreement respectively. For the statement *The management lecturers should teach sustainability related content*, only 1.3% and 2.8% of the responses were recorded for the strongly disagree and disagree category respectively. 11.3% of the responses were undecided, while the highest responses were for the agree and strongly agree category, with 48.2% and 36.3% respectively. As for the Social Science and Humanities lecturers, most of the responses were for the agree and strongly agree categories, with 44.1% and 39.7% of responses accordingly. 11.9% were undecided responses, while the remaining 4.4% were for the strongly disagree and disagree category. These results thus suggest that the respondents prefer all lecturers, regardless of their academic background to provide them with sustainability input. The mean scores obtained for these last four items were 4.34, 4.03. 4.15 and 4.18 respectively. These high scores indicate that respondents were in agreement that all lecturers regardless of their expertise should teach sustainability related content within the undergraduate engineering programme.

4.6.4.1.7 Final year undergraduate engineering students' responses to teaching and learning issues that should be considered in the engineering and non-engineering modules to help develop the desired sustainability learning experience in the university

In addition to Likert scale type items, the survey also consisted of an open-ended question. The purpose of the open-ended question was to elicit the final year undergraduate engineering student respondents' views on teaching and learning issues that should be considered in the engineering and non-engineering modules to help develop the desired sustainability learning experience in the university. The section that follows describes the results of the NVivo analysis conducted to categorize the views provided by the respondents. A total of 219 open-ended responses were noted for the analysis of the open-ended responses. The qualitative software NVivo version 10 was used to categorize these responses.

Table 4.31: Open-ended responses categorized by type of module

Engineering modules		Communication /Language/ Management/Social Science & Humanities modules	
Categories	**Number of references coded**	**Categories**	**Number of references coded**
Practical vs. Theoretical	19	Communication and sustainable development	12
Real sustainable development issues and situations	19		
Sustainable development learning activities and assessment	13	Approach to teaching sustainable development for non-engineering modules	50
The need for heightened exposure and awareness to sustainable development post-graduation	6		
Teaching and learning of sustainable development via knowledge of current technological trends	14	Bringing real life sustainable development issues and situations into non-engineering modules	13
Sustainable development awareness through exposure within the engineering industry	11		
Sustainable development content within current learning modules	13	Relating engineering aspects with human and societal aspects	19
Approach to teaching sustainable development	30		

A total of 12 categories were identified from the open-ended responses provided by the survey respondents. Eight of these categories were from the responses obtained for the Engineering modules, and the remaining four, for the Communication /Language / Management / Social Science & Humanities modules. Under the Engineering modules grouping, the category, *Approach to teaching sustainable development* had the highest number of responses, i.e. 30. The least number of responses were for the category *The need for heightened exposure and awareness to sustainable development post-graduation*, with six responses in total. As for the non-engineering modules grouping, the most number of responses were once again centered upon the category *Approach to teaching sustainable development for non-engineering modules*. A total of 50 responses made up this category. *Communication and sustainable development* which had 12 responses, was the category which had the least number of responses under the non-engineering modules grouping. The summary of the responses for each category will be highlighted during the discussion of the findings. The section that follows describes the results of the qualitative analysis for issue 4.

4.6.4.2 Issue 4 - Interview results

Interviews were conducted with academicians, university management, engineering industry practitioners, ESD experts, ESD practitioners and final year undergraduate engineering student respondents to gauge their perspectives on the pedagogies and curriculum to achieve and support sustainability education goals at the university. 12 sub-issues were identified to obtain a wider perspective of the pedagogies & curriculum to achieve and support EESD in the university, namely, (a) existing methods of teaching sustainable development or sustainable engineering and associated teaching & learning concerns, (b) institutional approach to sustainable development, the relevance of the hypothetical competences, suggested improvements to the hypothetical learning competences, (c) collaborative learning through sharing of knowledge and expertise by engineering & non-engineering lecturers, (d) communities of practice as a means of developing better understanding of sustainable development, (e) non-technical modules (language /communication, business, social science and humanities modules) as a platform for sustainable development competences development, (f) interdisciplinarity, multidisciplinarity and transdisciplinarity through ESD, (g) essential knowledge and skills to teach sustainable development, (h) engineering or non-engineering academicians for the teaching of sustainable development, (i) methods of providing sustainable development input, (j) philosophies and styles of teaching & learning for sustainable development. Themes are as detailed in Table 4.4. The results of the document analysis conducted for Issue 4 are presented in the next section.

4.6.4.3 Issue 4 – Document analysis results

The documents that were identified for review were the university's vision and mission statements, research vision and mission statements, undergraduate engineering programme educational objectives and programme outcomes and the common engineering and non-engineering module learning outcomes.

4.6.4.3.1 Document analysis results for the vision and mission statements and research vision and mission statements of the university in accordance to sustainable development competences and ESD competences

The results of the document analysis indicate the absence of manifest content, but the presence of latent content in relation to sustainable development competences and ESD competences. The document analysis conducted on the research vision and mission of the university also indicate the absence of manifest content but the presence of latent content in relation to sustainable development competences and ESD competences.

4.6.4.3.2 Document analysis results for sustainability competences in the various undergraduate engineering programme educational objectives and programme outcomes

This section describes the manifest and latent content related to sustainable development competences and ESD competences apparent in the undergraduate engineering programme educational objectives and programme outcomes of the university.

The university's main programme educational objective was initially *To produce technically qualified well-rounded engineers and technologists with the potential to become leaders of industry and the nation*. This objective was later modified. The modified version presently consists of two objectives, namely *To produce technically qualified engineers with the potential to become leaders of engineering industries* and *To produce engineers who are committed to sustainable development of engineering industries for the betterment of society and nation*. The programme educational objectives and programme outcomes of all undergraduate engineering programmes offered in the university had been modified to include sustainable development outcomes. The analysis of the educational outcomes for the present study would thus be a comparison between the former outcomes and the modified outcomes. Table 4.32 illustrates the former and modified programme educational objectives of the various undergraduate engineering programmes offered in the university.

Table 4.32: Former and modified Programme Educational Objectives (PEO) of Undergraduate Engineering Programmes

Programme	Former PEO	Modified PEO
Chemical Engineering	To produce technically qualified well-rounded Chemical Engineers with the potential to become leaders of industry and the nation	To produce technically qualified Chemical Engineers with the potential to become leaders in chemical process industries with emphasis on Oil and Gas
		To produce Chemical Engineers who are committed to *sustainable development* of chemical process industries for the *betterment of society and nation*
Civil Engineering	To produce technically qualified well-rounded Civil Engineers with the potential to become leaders of industry and the nation	To produce technically qualified Civil Engineers with the potential to become leaders of Civil Engineering Industries
		To produce Civil Engineers who are committed to *sustainable development* of Civil Engineering Industries for the *betterment of society and nation*
Electrical & Electronic Engineering	To produce technically qualified well-rounded Electrical and Electronic Engineers with the potential to become leaders of industry and the nation	To produce technically qualified Electrical & Electronics Engineers with the potential to become leaders of Electrical & Electronic Industries
		To produce Electrical & Electronics Engineers who are committed to *sustainable development* of Electrical & Electronic Industries for the *betterment of society and nation*
Mechanical Engineering	To produce technically qualified well-rounded Mechanical Engineers with the potential to become leaders of industry and the nation	To produce technically qualified Mechanical Engineers with the potential to become leaders of Energy and Manufacturing Sectors
		To produce Mechanical Engineers who are committed to *sustainable development* of Energy and Manufacturing Sectors for the *betterment of society and nation*
Petroleum Engineering	To produce technically qualified well-rounded Petroleum Engineers with the potential to become leaders of industry and the nation	To produce technically qualified Petroleum Engineers with the potential to become leaders of Oil and Gas Industries
		To produce Petroleum Engineers who are committed to *sustainable development* of Oil and Gas Industries for the *betterment of society and nation*

(Academic Central Services, University X)

As evident in Table 4.32, the former programme educational objectives of all undergraduate engineering programmes offered in the university did not contain any manifest or latent references to sustainability competences. However, the modified programme educational objectives of each programme contain one manifest and one latent reference. The phrase *sustainable development* indicates a manifest representation, while the phrase *betterment of society and nation* on the other hand denotes latent representation.

4.6.4.3.3 Document analysis results for sustainability competences in the undergraduate engineering programme outcomes

Table 4.33 to Table 4.37 represents the former and modified programme outcomes of the five undergraduate engineering programmes. The former and modified outcomes were sourced from the Academic Central Services unit of the university.

Table 4.33: Chemical Engineering Programme Outcomes (PO)

CHEMICAL ENGINEERING POs	
FORMER OUTCOMES	**MODIFIED OUTCOMES**
1. Apply chemical and engineering principles for problem identification, formulation and solution	1. Acquire and apply knowledge of basic sciences and engineering fundamentals
2. Apply in-depth technical knowledge to analyse, interpret, evaluate and improve system performance in one of the specialised areas (industrial environmental engineering, process plant engineering, gas and petrochemical engineering, process analysis and control and petroleum engineering	2. Acquire and apply Chemical Engineering principles and in-depth technical knowledge
3. Design process plants and improve performance by incorporating the concept of sustainable development	3. Ability to design, optimize and operate processes
4. Demonstrate professional ethics, leadership capacity and moral values	4. Undertake problem identification, formulation and solution by considering the concept of sustainable development
5. Function and communicate efficiently in a variety of professional context as an individual and in a group with the capacity to be a leader of manager	5. Comprehend social, cultural, global and environmental responsibilities of a professional engineer, and the need for sustainable development
6. Apply engineering and business knowledge in entrepreneurship	6. Communicate effectively in a professional context
7. Demonstrate the ability to work in team	7. Exhibit professional and ethical responsibilities
8. Undertake the independent study and engage in life-long learning	8. Demonstrate leadership, business acumen and entrepreneurship
	9. Demonstrate the capacity to undertake lifelong learning

(Source: Academic Central Services, University X)

Table 4.34: Civil Engineering Programme Outcomes (PO)

CIVIL ENGINEERING POs	
FORMER OUTCOMES	**MODIFIED OUTCOMES**
1. Acquire and apply knowledge of basic civil engineering fundamentals	1. Acquire and apply knowledge of basic civil engineering fundamentals
2. Practice in-depth technical competence in any specific civil engineering discipline	2. Practice in-depth technical competence in any specific civil engineering discipline
3. Undertake problem identification, formulation and solution	3. Identify, formulate and solve problems using creativity and innovation
4. Utilize systems approach to evaluate operational performance and application software	4. Utilize systems approach to evaluate operational and maintenance performance and application software
5. Demonstrate the principles of entrepreneurship, sustainable design and development	5. Demonstrate the principles of entrepreneurship, sustainable design and development
6. Practice, with commitment the professional and ethical responsibilities	6. Practice professional and ethical responsibilities
7. Communicate effectively with all levels of industry and society	7. Communicate effectively with all levels of industry and society
8. Perform effectively as an individual and in a team with the capacity to be a leader or manager	8. Perform effectively as an individual and in a team with the capacity to be a leader or manager
9. Demonstrate the understanding of the social, cultural, global and environmental responsibilities of a professional engineer, and the need for sustainable development	9. Demonstrate the understanding of the social, cultural, global and environmental responsibilities of a professional engineer, and the need for sustainable development
10. Recognize, acquire and possess the need to undertake life-long learning and professional development	10. Recognize, acquire and possess the need to undertake life-long learning and professional development
11. Analyse and optimize contractual and financial implications on project selections	11. Analyse and optimize contractual and financial implications on project selections

(Source: Academic Central Services, University X)

Table 4.35: Electrical & Electronic Engineering Programme Outcomes (PO)

ELECTRICAL & ELECTRONIC ENGINEERING POs	
FORMER OUTCOMES	**MODIFIED OUTCOMES**
1. Apply mathematics, physical science, and engineering principles in problem identification, formulation and solution in relation to practical solutions	1. Ability to acquire and apply knowledge of basic science and engineering fundamentals
2. Acquire and apply in-depth and current technical knowledge and practices in electrical & electronics engineering	2. Acquire in-depth technical competence in a specific engineering discipline
3.Utilize systems approach to design and evaluate operational performance and ensure sustainable development	3. Ability to undertake problem identification, formulation and solution in electrical & electronics engineering
4. Demonstrate sense of professional and ethical responsibilities towards environment and society	4. Ability to utilize a systems approach to design and evaluate operational performance in electrical & electronics engineering
5.Function and communicate effectively in a variety of professional context as an individual and in a group with the capacity to be a leader or manager	5. Ability to demonstrate the understanding of the principles of sustainable design and development
6. Undertake independent study and engage in life-long learning	6. Ability to demonstrate the understanding of professional and ethical responsibilities and commitment to them
7. Apply engineering and business knowledge in entrepreneurship	7. Ability to communicate effectively, not only with engineers, but also with the community at large
	8. Ability to function effectively as an individual and in a group, with the capacity to be a leader or manager, as well as effective team member
	9. Ability to undertake social, cultural, global and environmental responsibilities of a professional engineer
	10. Ability to undertake life-long learning, and possessing/acquiring the capacity to do so
	11. Demonstrate business acumen and entrepreneurship in specific engineering, and other related businesses

(Source: Academic Central Services, University X)

Table 4.36: Mechanical Engineering Programme Outcomes (PO)

MECHANICAL ENGINEERING POs	
FORMER OUTCOMES	**MODIFIED OUTCOMES**
1. Apply knowledge of science and engineering principles in mechanical engineering systems, processes and applications	1. Ability to acquire and apply knowledge of science and engineering fundamentals
2. Apply knowledge of mechanical engineering fundamentals to evaluate and solve engineering problems using specific tools and techniques	2. Ability to undertake problem identification, formulation and solution in mechanical engineering
3. Demonstrate an in-depth technical competency in mechanical engineering specialization	3. Ability to acquire in-depth technical competence in a mechanical engineering discipline
4. Undertake design, analysis and synthesis in industry based problem solving	4. Ability to utilize systems approach to design and evaluate operational performance in mechanical engineering
5. Demonstrate professionalism and ethical practices in society	5. Understanding of the principles of design for sustainable development
6. Demonstrate business acumen and entrepreneurship in mechanical engineering and other related businesses	6. Understanding of professional and ethical responsibilities and commitment to them
7. Function and communicate effectively in a variety of professional context as an individual and in a team based approach, with the capability to be a leader or manager	7. Understanding of the social, cultural, global and environmental responsibilities of a professional engineer
8. Engage in life-long learning and independent study	8. Demonstrating business acumen and entrepreneurship in mechanical engineering, and other related businesses
	9. Ability to communicate effectively, not only with engineers, but also with the community at large
	10. Ability to function effectively as an individual and in a group, with the capacity to be a leader
	11. Recognizing the need to undertake life-long learning, and possessing/acquiring the capacity to do so

(Source: Academic Central Services, University X)

Table 4.37: Petroleum Engineering Programme Outcomes (PO)

PETROLEUM ENGINEERING POs	
FORMER OUTCOMES	**MODIFIED OUTCOMES**
1. Apply the knowledge of mathematics and sciences in petroleum engineering domains	1. Ability to apply knowledge of science and engineering fundamentals
2. Formulate and solve petroleum engineering related problems using relevant tools and techniques	2. Technical competency in petroleum engineering disciplines
3. Design sustainable processes and systems for petroleum engineering applications	3. Ability to undertake problem identification, formulation and solution in petroleum engineering
4. Act and network with people in related industries, ethically and professionally	4. Ability to utilise systems analysis approach to design and to evaluate performance in petroleum engineering
5. Communicate effectively in written and oral form	5. Understanding of the principles of design for sustainable development
6. Work in multidisciplinary teams	6. Understanding of and commitment to professional and ethical responsibilities
7. Perform effectively as an individual and in a team with the capacity to be a leader or manager	7. Ability to communicate effectively, not only with engineers, but also with the community at large
8. Engage in lifelong learning and professional development	8. Ability to function in a group, with the capacity to become a leader
9. Demonstrate business acumen in petroleum and other related businesses	9. Ability to undertake the social, cultural, global and environmental responsibilities of a professional engineer
	10. Recognition of the need to undertake lifelong learning
	11. Ability to demonstrate business acumen and entrepreneurship in petroleum engineering, and other related businesses

(Source: Academic Central Services, University X)

Tables 4.33 to 4.37 project the former and modified programme outcomes of the five undergraduate engineering programmes offered in University X. As highlighted in the tables, it is evident that all five modified programme outcomes have increased total outcomes, in comparison to its original total. Table 4.38 highlights the gist of the results of the document analysis for the programme outcomes of these five engineering programmes. The analysis took into account the following issues, (a) number of former and modified programme outcomes related to sustainability competences, (b) percentage of sustainability competences within the total former and modified outcomes.

Table 4.38: Mapping of programme outcomes to sustainability competencies

CHEMICAL ENGINEERING PROGRAMME			
FORMER POs		**MODIFIED POs**	
POs related to sustainability competences	3, 4, 6, 7 (4 out of 8 outcomes)	POs related to sustainability competences	4,5,7,9 (4 out of 9 outcomes)
Percentage of sustainability competences within the total outcomes	50%	Percentage of sustainability competences within the total outcomes	44.4%
Difference between programme’s sustainability competences percentage and EAC’s sustainability competence percentage (66.7%)	16.7% ↓	Difference between programme’s sustainability competences percentage and EAC’s sustainability competence percentage (66.7%)	22.3% ↓
CIVIL ENGINEERING PROGRAMME			
FORMER POs		**MODIFIED POs**	
POs related to sustainability competences	4,5,6,8,9,10 (6 out of 11 outcomes)	POs related to sustainability competences	3,4,5,6, 8, 9, 10 (7 out of 11 outcomes)
Percentage of sustainability competences within the total outcomes	54.5%	Percentage of sustainability competences within the total outcomes	63.6%
Difference between programme’s sustainability competences percentage and EAC’s sustainability competence percentage (66.7%)	12.2% ↓	Difference between programme’s sustainability competences percentage and EAC’s sustainability competence percentage (66.7%)	3.1% ↓
ELECTRICAL AND ELECTRONIC ENGINEERING PROGRAMME			
FORMER POs		**MODIFIED POs**	
POs related to sustainability competences	3,4,6 (3 out of 7 outcomes)	POs related to sustainability competences	4,5,6,8,9,10 (6 out of 11 outcomes)

Percentage of sustainability competences within the total outcomes	42.9%	Percentage of sustainability competences within the total outcomes	54.5%
Difference between programme's sustainability competences percentage and EAC's sustainability competence percentage (66.7%)	23.8% ↓	Difference between programme's sustainability competences percentage and EAC's sustainability competence percentage (66.7%)	12.2% ↓
MECHANICAL ENGINEERING PROGRAMME			
FORMER POs		**MODIFIED POs**	
POs related to sustainability competences	5,8 (2 out of 8 outcomes)	POs related to sustainability competences	4,5,6,7,10,11 (6 out of 11 outcomes)
Percentage of sustainability competences within the total outcomes	25%	Percentage of sustainability competences within the total outcomes	54.5%
Difference between programme's sustainability competences percentage and EAC's sustainability competence percentage (66.7%)	41.7%↓	Difference between programme's sustainability competences percentage and EAC's sustainability competence percentage (66.7%)	12.2% ↓
PETROLEUM ENGINEERING PROGRAMME			
FORMER POs		**MODIFIED POs**	
POs related to sustainability competences	3,6,7,8 (4 out of 9 outcomes)	POs related to sustainability competences	4,5,6,8,9,10 (6 out of 11 outcomes)
Percentage of sustainability competences within the total outcomes	44.4%	Percentage of sustainability competences within the total outcomes	54.5%
Difference between programme's sustainability competences percentage and EAC's sustainability competence percentage (66.7%)	22.3% ↓	Difference between programme's sustainability competences percentage and EAC's sustainability competence percentage (66.7%)	12.2% ↓

As highlighted in Table 4.38, there are evidences of manifest and latent sustainability competences in all undergraduate engineering programme outcomes. However, the percentages of sustainability competences within all programmes differ in the former and modified outcomes. In addition, all programme outcomes related to sustainability competences are sustainable development competence focused rather than ESD focused.

In the Chemical Engineering former programme outcomes, a total of 4 out of the 8 competences were in reference to sustainability competences. This amounted to 50% of the total outcomes. In the modified programme outcomes, a total of 4 out of the 9 competences were in relation to sustainability competences, representing 44.4% of the total. This indicates that there has been a 5.6% decrease in the percentage of outcomes related to sustainability competencies when the former outcomes were modified to the current outcomes. In addition, the institution's current sustainability competences percentage is 22.3% less than the Malaysian Engineering Accreditation Council's sustainability competences percentage of 66.7%.

In relation to the Civil Engineering former programme outcomes, a total of 6 out of the 11 competences were in reference to sustainability competences. This amounted to 54.5% of the total outcomes. In the modified programme outcomes, a total of 7 out of the 11 competences were in relation to sustainability competences, representing 63.6% of the total percentage of outcomes. This indicates that there has been a 9.1% increase in the percentage of outcomes related to sustainability competencies. The institution's sustainability competences percentage is 3.1% less than the Malaysian Engineering Accreditation Council's sustainability competences percentage of 66.7%.

The Electrical and Electronics Engineering programme had 7 former programme outcomes. Of these outcomes, 3 out of the 7 outcomes were related to sustainability competences. In the modified outcomes, 6 out of the total 11 outcomes are related to sustainability competences. The former and modified sustainability competences percentages are 42.9% and 54.5% respectively. This indicates an 11.6% increase in sustainability competences outcomes for this undergraduate engineering programme. The institution's sustainability competences percentage is 12.2% less than the Malaysian Engineering Accreditation Council's sustainability competences percentage of 66.7%.

In the case of the former Mechanical Engineering programme outcomes, 2 outcomes of the total 8 outcomes were related to sustainability competences. This represented 25% of the total programme outcomes. In the modified outcomes, of the total 11 outcomes, 6 were in relation to sustainability competences, representing 54.6% of the total. This denotes a 29.6% increase in sustainability competences for Mechanical Engineering programme. The institution's sustainability competences percentage is 12.2% less than the Malaysian Engineering Accreditation Council's sustainability competences percentage of 66.7%.

The final programme, Petroleum Engineering, had 4 out of 9 former outcomes related to sustainability competences. This represented a 44.4% of sustainability competences of the total former outcomes. In the modified outcomes, 6 out of the 11 outcomes were in relation to sustainability competences, representing 54.5% of the total. This shows a 10.1% percent increase in sustainability competences outcomes for the Petroleum engineering undergraduate programme. The institution's sustainability competences percentage is 12.2% less than the Malaysian Engineering Accreditation Council's sustainability competences percentage of 66.7%.

Overall, the results suggest that there has been an increase in sustainability competences in the programme outcomes of the Civil, Electrical and Electronic, Mechanical and Petroleum engineering programmes. The Chemical engineering programme however recorded a decrease. The results also suggest that the Mechanical engineering programme has the highest difference in the percentage of sustainability competences in its former and modified programme outcomes, i.e. 29.5%. This is followed by the Electrical and Electronics programme, Petroleum engineering programme and finally the Civil engineering programme with 11.6%, 10.1% and 9.1% increase respectively. In relation to the difference between the institution's current sustainability competences percentage and the Engineering Accreditation Council's sustainability competence percentage of 66.7%, all engineering programmes recorded lower percentages, with the Chemical engineering programme having the highest decrease at 22.3%.

The following section discusses the sustainability competences in the common engineering and non-engineering module learning outcomes.

4.6.4.3.4 Document analysis results for sustainability competences in the common engineering and non-engineering module learning outcomes

This section describes the manifest and latent content related to sustainable development competences and ESD competences apparent in the common engineering and non-engineering modules. For the purpose of the present study, the following modules listed below have been identified for the document analysis:

Common Engineering modules:

a. Health, Safety & Environment
b. Engineering Economics & Entrepreneurship
c. Engineers in Society
d. Engineering Team Project
e. Probability & Statistics
f. Introduction to Management

University Requirement modules:

a. Introduction to Oil & Gas Industry and Sustainable Development (*formerly known as Introduction to Oil & Gas Industry*)
b. Professional Communication Skills (PCS)
c. Academic Writing

The Academic Writing module is categorized as a Common Engineering module for 3 out of the 5 engineering programmes. The learning outcomes and content of the module is the same across all engineering programmes.

National Requirement module:

a. Malaysian Studies
b. Islamic Studies / Moral Studies

The Islamic Studies / Moral Studies modules are not included in the document analysis as Islamic Studies is only taken by the Muslim students, while Moral Studies is taken only by the non-Muslim students. Hence these modules do not fit the common module criteria used for the present study, as both modules are taken in accordance to the student's religious beliefs. Table 4.39 to Table 4.41 highlight the learning outcomes of the modules identified for the document analysis.

Table 4.39: Module learning outcomes

MODULE LEARNING OUTCOMES			
Health, Safety & Environment	**Engineering Economics & Entrepreneurship**	**Engineers in Society**	**Engineering Team Project**
1. Describe current regulations and law relating to *health, safety and environment and the role of engineers and technologists* as HSE personnel or employee. *2.* Evaluate and relate *environmental* hazards and concerns with regards to key principles of *sustainable development* 3. Identify and analyse hazards using hazard identification methods and techniques in the workplace 4. Analyse and assess HSE components in any given case studies, accidents and failures 5. Relate safety issues to the design and operation of equipment to their disciplines 6. Recognize suitable mitigation techniques to eliminate or reduce hazards	1. Describe the monetary side of engineering, the basic concepts of engineering economy and its underlying principles 2. Discuss and apply the various methodology of engineering economy and their application that will assist in making rational decision or solution to engineering problems that will be encountered in practice 3. Discuss and *solve problems* related to the advanced topics such as interests, depreciation, depletion, income taxes, effect of inflation, tools for evaluating alternatives, capital financing, replacement analysis and project risk and uncertainty 4. Discuss the use of decision tree analysis in situations involving risk and uncertainty and illustrate how they can be applied in engineering economic analysis	1. Demonstrate *the role of engineers in society* according to Engineers' Act 1997 2. Apply basics of Operation and Project Management 3. Implement requirements of *Environmental legislation* in projects 4. Apply basic Quality Management Tools 5. Discuss the business and legal aspects in an engineer's work	1. Apply engineering knowledge and solve engineering design problem 2. *Work in a multi-disciplinary team-based* project work 3. Apply the principle of project management *4.* Apply proper design process *to produce creative and innovative solution* 5. Demonstrate effective communication, report writing, presentation and entrepreneur skills

Table 4.40: Module learning outcomes (cont.)

MODULE LEARNING OUTCOMES			
Probability & Statistics	**Introduction to Management**	**Introduction to Oil & Gas Industry and Sustainable Development**	**Professional Communication Skills**
1. Identify the role of Statistics in the analysis of data from engineering and science 2. Capture principle notions and rules of probability, conditional probability, independent events. Apply the total probability formula and Bayes' rule 3. Identify discrete and continuous random variables, their probability distribution (mass probability function and density probability function) 4. Determine the critical values for well-known distributions: normal distribution, chi-squared distribution, student t-distribution, and F-distribution 5. Identify the important role of random samples, their characteristics (sample mean, sample variance,) particular of normal sample. Apply the Central Limit Theorem (CLT), laws of large Numbers (LLN) 6. Estimate parameters and characteristics using point estimators and confidence intervals. Perform Hypothesis Tests and construct confidence intervals 7. Perform Hypothesis Tests and construct confidence intervals 8. Determine coefficients of the linear regression model, using the Least Squares Method. Use the ANOVA in testing the model 9. Use the factorial design approach to design and conduct engineering experiments involving several factors	1. Describe the four basic management functions of planning, organizing, leading and controlling across an organization 2. Explain the application of some basic management principles in an increasingly global business environment *3.* Understand the importance of *behaving in a professional and ethical manner* 4. Have an appreciation of the importance of management to an organization	1. Describe the various steps of the petroleum industry life cycle and understand which disciplines are involved at each step 2. Explain how oil and gas are discovered and produced 3. Explain how oil and gas are transported from the site of production to refineries or treatment plants 4. Explain how oil and gas are treated and exported to markets 5. Describe various petrol and petrochemical products *6.* Describe knowledge and principles of *sustainable development* 7. Explain the concept of legacy of *unsustainable world* 8. Able to relate the patterns of *development and sustainable development with the role of engineers* in industry 9. Explain various types of *footprints and the relation with sustainable development*	1. apply the principles and practices of professional oral communication skills 2. present information confidently, accurately and fluently in a variety of professional, business and social settings 3. persuade effectively in a variety of professional, business and social settings 4. communicate interpersonally, and *work effectively individually and in teams*

Table 4.41: Module learning outcomes (cont.)

MODULE LEARNING OUTCOMES	
Academic Writing	**Malaysian Studies**
1. identify the structure of an academic research paper 2. use English accurately and effectively in producing written texts 3. apply the process of writing when producing written texts 4. produce coherent and cohesive written texts	1. explain the history of the country and people, as well as the development of the Malaysian society in socio-cultural, political and economic terms 2. recognize the efforts and contributions of those who were involved in defending the county's honour and sovereignty 3. relate the nation's identity and be proud as the country's citizen 4. recognize Malaysia's role and contribution in international arena

(Source: Academic Central Services, University X)

Tables 4.39 to 4.41 list the learning outcomes of the 10 modules identified for the document analysis. Of the 10 modules, Engineering Economics & Entrepreneurship, Introduction to Management, Professional Communication Skills, Academic Writing and Malaysian Studies are offered by the Department of Management and Humanities. The remaining five modules are offered by the Engineering departments. The paragraphs that follow will summarize the main results of the manifest and latent analysis.

In the *Health, Safety and Environment* module, outcomes 1 and 2 are linked to sustainability competences. Outcome 1 contains the phrase *health, safety and environment and the role of engineers and technologists*, indicating latent reference. This phrase suggests sustainable development competences, as opposed to ESD competences. Outcome 2 on the other hand contains both latent and manifest references to sustainable development competences, with the phrase *environmental hazard* indicating latent reference and the phrase *sustainable development* indicating manifest reference. As such, the 2 learning outcomes out of the total 6 outcomes of this module indicate a 33.3% reference to sustainability competences. Additionally, the outcomes *analyse and assess HSE components in any given case studies, accidents and failures* and *relate safety issues to the design and operation of equipment to their disciplines* indicate an attempt to use ESD teaching and learning approaches. The use of case studies for instance is a teaching and learning approach related to ESD. However, the particular learning outcome suggests that the case studies are not presented within the context of sustainable development. Furthermore, the module also seems to be rather discipline centric, as it seeks students to relate safety issues to the specific engineering disciplines they are enrolled in.

The *Engineers in Society* module contain two latent references to sustainable development competences. These references are found in outcomes 1 and 3 of the module. The phrases *the role of engineers in society* in outcome 1 and *environmental legislation* in outcome 3 illustrate these latent references. The results thus indicate that 2 out of the 5 learning outcomes represent a 40% reference to sustainability competences in this module.

The *Engineering Team Project* module contains a total of 5 learning outcomes. Of the 5 outcomes, outcomes 2 and 4 are in reference to sustainability competences, specifically sustainable development competences. This is evident through the use of phrases such as *work in a multidisciplinary team-based project* and *to produce creative and innovative solution*. These results therefore suggest that 40% of the learning outcomes of the Engineering Team Project module are devoted to the development of sustainability competences. Interestingly, although the learning outcomes have been worded to reflect sustainable development competences, these phrases nevertheless do also suggest the presence of ESD competences. The multidisciplinary team-based project and production of creative and innovative solutions are indications of teaching and learning approaches related to ESD.

In the *Introduction to Management* module, there seems to be no evidence of manifest references to sustainable development and ESD competences. However, outcome 3, *Understand the importance of behaving in a professional and ethical manner*, seems to suggest a latent reference to sustainable development related competences. Nevertheless, as the module as a whole is not developed within the context of sustainable development, its standing as a sustainability competences related learning outcome is therefore insignificant.

The *Introduction to Oil and Gas Industry and Sustainable Development* module is an only common module with a very explicit reference to sustainable development. Out of a total of 9 learning outcomes, 4 outcomes, namely outcomes 6, 7, 8, and 9, are in relation to sustainability competences. Phrases such as *sustainable development*, *unsustainable world*, *development and sustainable development with the role of engineers* and *footprints and the relation with sustainable development* are manifest references to sustainable development competences. There are no indications of ESD competences in the learning outcomes of this module. The results for this module therefore suggest that 44.4% of the learning outcomes are devoted to the development of sustainability competences.

Similar to the *Introduction to Management* module, the *Professional Communication Skills* module has not been developed within the context of sustainable development or ESD. However, outcome 4 which contains the phrase *work effectively individually and in teams* is an indication of the use of an approach related to ESD. However, its standing as a sustainability competences related learning outcome is insignificant, given the fact that the module had not been developed to reflect sustainability competences.

Four modules, namely *Engineering Economics & Entrepreneurship*, *Probability and Statistics*, *Academic Writing* and *Malaysian Studies* do not contain any manifest and latent references to sustainability competences, be it sustainable development competences or ESD competences. These modules have also not been developed to reflect sustainable development and ESD contexts. Table 4.42 depicts the summary of the results of the sustainability competences learning outcomes percentage for each module.

Table 4.42: Sustainability competences learning outcomes percentage in common undergraduate engineering modules

Name of module	Sustainability competences percentage
Health, Safety & Environment	33.3%
Introduction to Oil & Gas Industry and Sustainable Development	44.4%
Engineers in Society	40%
Engineering Team Project	40%
Probability & Statistics	0%
Introduction to Management	0%
Engineering Economics & Entrepreneurship	0%
Professional Communication Skills	0%
Academic Writing	0%
Malaysian Studies	0%

As described in Table 4.42, four of the ten modules contain learning outcomes related to sustainability competences. The Introduction to Oil & Gas Industry and Sustainable Development module contains the highest percentage of sustainability competences with 44.4%. This is followed by the Engineers in Society module and the Engineering Team Project module which each contain 40% of learning outcomes related to sustainability competences. The module Health, Safety and Environment contain 33.3% of learning outcomes related to sustainability competences. It can thus be summarized that 40% of the total 10 common modules have learning outcomes related to sustainability competences.

4.6.5 Malaysian and international ESD stakeholders' responses on suggested improvements for the 30 competences for inclusion in the Malaysian undergraduate engineering education curriculum

This section highlights the reviews provided by the Malaysian and international ESD stakeholders' on suggested improvements for the 30 sustainable development competences. The reviews were conducted by a UNESCO Chair in Social Learning and Sustainable Development, two Professors of ESD from the United Kingdom, a Professor of Social Sciences and Humanities from Malaysia, two ESD practitioners, two academicians and five engineering industry practitioners.

12 of the 13 respondents who provided their comments had also responded to the survey in which they had to indicate their agreement or disagreement on the relevance of the 30 competences (results in Table 4.17). Table 4.43 presents the UNESCO Chair's review and suggested improvements while Table 4.44 represents the reviews and suggested improvements of the remaining reviewers.

Table 4.43: Review and suggested improvements from UNESCO Chair

	UNESCO EXPERT REVIEW OF THE HYPOTHETICAL SUSTAINABLE DEVELOPMENT COMPETENCES FOR MALAYSIAN ENGINEERING EDUCATION
	REVIEWER: UNESCO CHAIR IN SOCIAL LEARNING AND SUSTAINABLE DEVELOPMENT
SUGGESTIONS	1. All 30 competences are appropriate and relevant to engineering programme outcomes and module learning outcomes. 2. Having too many competences may not necessarily indicate comprehensiveness, but could also signify that it is too focused. This could sometimes be viewed as a limitation of long lists. 3. Researcher's acknowledgement of the limitations of long lists (in the form of a condition or disclaimer) should be added as a notation to the development of the final list of outcomes. 4. Acknowledgement of the limitations of long lists would serve as a cautionary measure to end users of the final list of outcomes, so they could exercise their own judgement as to which competences they would like to include in the educational modules taught. 5. It would be better to label them as competence rather than knowledge, skills and values. This is because competence is something you show when you need to respond to something. 6. In an outcome based educational system, using knowledge, skills and values as indicators is permissible.

Table 4.44: Suggested improvements from ESD experts, practitioners, industry and academicians

RESPONDENT CATEGORY	SUGGESTIONS
ESD EXPERTS	1. Use the term competence instead of knowledge, skills and values (EP 2) 2. Use the term competence, so it is more aligned with recent international dialogues in ESD (EP 9) 3. Make a distinction between competences which are specific to engineering and those that are generic (EP 2) 4. Develop framework with the context in mind (EP 2) 5. Communication and language skills must not be used to only address community and societal problems (EP 3)

	6. Address problems and issues facing a nation from cultural, historical and geographical points of views (EP 3)
ESD PRACTITIONERS	1. The 30 competences can be viewed as an overall framework (EP 7) 2. Specific learning outcomes can be extracted from the list of 30 competences to develop learning outcomes for various modules (EP 7) 3. Instead of using terms such as knowledge, skills and values, terms such as 'holistic approach' 'implications for engineering' can be used to group the 30 competences (EP 7) 4. 4. Verbs such as 'understand', 'appreciate' and 'apply' can be difficult to assess (EP 4)
ACADEMICIANS	1. Business and management skills may not be so relevant for engineering modules but could be included as outcomes in student projects (A 4) 2. Include generic examples of topics related to sustainable development that can be used as issues for discussion in the modules (A 9)
INDUSTRY PRACTITIONERS	1. Expand the term 'holistic' to make it more comprehensible (IP 3). 2. Industry definition of holistic is the inclusion of technical, environmental, human, societal and cultural aspects (IP 4) 3. Change the term 'complex problem' to 'community based problems' (IP 4) 4. Rephrase the term 'play the role of responsible citizens at the local and global level' to 'contribution to the nation' or remove the outcome (IP 4) 5. Rephrase the outcome 'respect and value cultural, social, economic and biodiversity ' to include the aspect of religion (IP 4) 6. Include specific deliverables for communication skills (IP 4) 7. Include the element of 'engineering development' in the list of outcomes as engineering development is a vital aspect of the engineering process (IP 3) 8. Include 'future' aspects in the outcome 'Appreciation that current aspects can impact on the quality of life of future generations' (IP 3) 9. Business and management skills can be expanded to include implementation of sustainable business model and making business decisions (IP 3)

	10. Cost cutting measures, loss of production time, minimizing energy wastage, operating cost impact and energy management are elements related to business and management skills (IP 6) 11. Negotiation skills in selection of vendors and raw material suppliers that practice sustainable measures in their business (IP 6) 12. Communication skills must include the ability to express ideas with a variety of people involved in the engineering and business context i.e. the customers, the sales personnel, the marketing personnel, the process and product development engineers, the production personnel, the finance personnel and the administration personnel (IP 6) 13. Ability to express ideas and opinions to colleagues of the same level and members from the middle and upper management are vital communication skills for engineers to be able to practice sustainable engineering (IP 3) 14. Two way communication is an important communication skills for engineers to have within the context of sustainability (IP 6) 15. Communication skills should include ability to talk and explain intelligently and sensibly (IP 1) 16. Include aspects of sustainable engineering culture i.e. sustainable norms and codes engineering practices (IP 1) 17. Communication skills competence must include the ability to discuss and promote ideas within a sustainable engineering context (IP5)

4.6.6 Data analysis results for issue 5 - Issues to consider for the incorporation of Sustainability Education within the engineering programme

This was the final issue explored in the present study. Views of stakeholders from multiple levels of the university were sought in exploring these sub-issues in greater detail. Respondents included academicians, university management, final year undergraduate engineering students and practitioners from the engineering industry. The views of ESD experts as well as practitioners were also instrumental towards understanding these issues better.

Nine sub-issues were explored through this issue, namely: (a) benefits and challenges to academicians in relation to ways of approaching the teaching of sustainable development and placing sustainable development in the curriculum, (b) dealing with sustainable development content, (c) defining holistic understanding of sustainable development or sustainable engineering, (d) the university-internship-workplace ties in relation to sustainable development, (e) holistic approach to sustainable development by the university, (f) support for academicians, (g) sustainable development opportunity provision besides formal academic input for university stakeholders, (h) improving institutional practices for advancement of sustainable development in the university, (i) development of sustainable development competences for effective practice of sustainable engineering in the workplace. Themes are as detailed in Table 4.4.

4.7 Conclusion

This chapter focused upon the results of this mixed methods study. The aim of the chapter was to describe the results of the quantitative and qualitative dimensions of the study separately before converging the results to discuss the findings of the study. The interpretation of the results were not included in the present chapter, but are discussed at greater length in Chapters 5 to 7. Evidence (quotations) from the interviews is also included to substantiate the discussion of the findings. This also enables valid conclusions to be drawn about the research issues of this study.

CHAPTER 5

DISCUSSION OF FINDINGS

EESD AND THE PRESENT UNDERGRADUATE ENGINEERING CURRICULUM

5.0 Introduction

Chapters 5 to 7 discuss the major findings that have emerged from the results of the study using the theoretical positions presented in Chapter 2. References will also be made to literature and previous studies quoted in Chapter 2, where relevant. The findings presented in these chapters will be discussed in accordance to the research questions developed for the study. This is in contrast to the manner in which the results of the study were presented in Chapter 4, i.e. by the five broad categories explored through the study. The presentation of the findings using the research questions as a basis enables the findings of the study to be discussed in a more systematic manner. The first research question sought to explore the amount of emphasis University X placed on incorporating sustainable development and ESD within the curriculum of its undergraduate engineering programme.

5.1 Key findings of document analysis on the extent to which manifest and latent references to sustainable development and ESD are incorporated within educational philosophies of the undergraduate engineering curriculum

The results of the analysis of the manifest and latent content in the university's academic and research vision and mission statements suggest that sustainable development competences and ESD competences are not featured in an explicit manner within the university's academic and research focuses. A possible reason for these findings is the context in which these statements have been developed. The university's academic and research vision and mission statements have been drawn up within the context of national development, as well as the advancement of engineering, science, technology and R&D. This suggests that the university's core academic and research philosophies are centered upon the development of technologically savvy engineering graduates, instead of sustainability savvy graduates who would be able to contribute to the nation's progress, but not within a sustainable context. Implicitly however, the results of the analysis point to evidence of latent references to sustainable development and ESD competences. Nevertheless, to associate these latent references of sustainable development and ESD competences as an indication that the university has incorporated both, sustainable development and ESD within its curriculum, would be erroneous, given the context in which these vision and mission statements were developed in.

As mentioned in the previous chapter, the university made changes to the programme educational objectives and programme outcomes of all engineering programmes it offers at the undergraduate level. Prior to this change, the university had a sole programme educational objective, which was *To produce technically qualified well-rounded engineers and technologies with the potential to become leaders of industry and the nation***.** This objective did not contain any references to competences related to sustainable development and ESD. This objective was then altered to the present version which consists of two objectives. These new programme educational objectives contain explicit (manifest) and implicit (latent) references to sustainability competences, in comparison to the former objective which contained no references of these competences. The term *sustainable development* which is now apparent in the second modified programme educational outcomes of all five undergraduate engineering programmes is indicative of manifest representations of the university's endeavours to develop their undergraduate engineering student's sustainable development competences, while *betterment of society and nation* which is also seen in the second modified programme educational outcome of all five undergraduate engineering programmes signals latent representation. It is interesting to find that the manifest representations of these competences are seen to be more explicitly mentioned in the university's revised programme educational outcomes, in comparison to its academic vision and mission statements. This suggests that the university has placed more emphasis on the inclusion of sustainability competences within its programmes educational outcomes, instead of its academic and research philosophies.

In relation to the analysis of the programme outcomes of all five undergraduate engineering programmes, the results of the study suggest a moderate increase in the percentage of former and modified programme outcomes related to sustainable development competences. Four out of five modified undergraduate engineering programme outcomes recorded an increase in the percentage of outcomes developed within a sustainability lens, with the exception of the modified programme outcomes of the Chemical Engineering programme, which recorded a decrease. The Mechanical Engineering modified programme outcomes however recorded the highest increase for outcomes related to sustainable development competences. When compared against the Engineering Accreditation Council's percentage of sustainability related competences which stands at 66.7%, the sustainability competences percentages for all five undergraduate engineering programmes recorded lower percentages than that of the Engineering Council, with the Chemical engineering programme having the sharpest decrease at 22.3%. It has also been found that all programme outcomes related to sustainability competences have been developed within the focus of sustainable development competences instead of ESD competences.

The results of the manifest and latent analysis of the ten modules categorised as common engineering and non-engineering modules in the undergraduate engineering curriculum indicate that 40% or 4 modules of the 10 modules offered have learning outcomes related to sustainable development and ESD competences. It was found that 90% of the engineering and non-engineering modules have not been developed within the context of sustainable development, with the exception of the *Introduction to Oil & Gas Industry and Sustainable Development.* The results also indicate that none of the five modules offered by the Department of Management and Humanities, namely *Engineering Economics & Entrepreneurship*, *Academic Writing, Malaysian Studies*, *Professional Communication Skills* and *Introduction to Management* have been developed using a sustainable development or ESD lens. The results however indicate the use of teaching and learning approaches related to ESD, i.e. case studies, problem solving activities, individual and multidisciplinary group based activities in some of the engineering and non-engineering modules such as *Health, Safety and Environment, Engineering Team* Project, *Engineering Economics & Entrepreneurship* and *Professional Communication Skills*. However, the learning outcomes which describe the above mentioned teaching and learning approaches suggests that these strategies are not being employed within the context of ESD, or to develop undergraduate engineering students' sustainable development competences. Although ESD advocates the need for interdisciplinary, multidisciplinary and transdisciplinary approaches to teaching and learning, the results of the manifest and latent analysis of all common engineering and non-engineering modules however show a strong discipline centric focus to content development, as observed in the manner in which the learning outcomes have been formulated.

5.2 Key findings of the student stakeholders survey on the extent of the practice of sustainable development and ESD in the undergraduate engineering curriculum

The survey findings suggest that the university, as well as the undergraduate engineering programme, promote the importance of making sustainable development a practice within the institution. In relation to imparting the message of the need to practise sustainability through the modules taught at the undergraduate level, students were of the view that it was only their Engineering and Management modules lecturers who were doing so, while the Social Science and Humanities lecturers discussed it within a very limited scope. The results however suggest that the Language and Communication lecturers do not discuss the importance for engineering students to practice sustainability through these modules. It can thus be summarized that the English Language and Communication lecturers are the least to discuss the importance for engineering students to practice sustainability through the English Language and Communication modules. The Social Science and Humanities lecturers were the second least to discuss the necessity for engineering students to practice sustainability through their modules. The lecturers who did discuss the importance for engineering students to practice sustainability the most were the Engineering lecturers, followed by the Management lecturers.

Findings on teaching and learning approaches presently used in the undergraduate engineering classroom suggest that the students were in strong agreement for their engineering and non-engineering lecturers to practice the sharing of knowledge on best approaches to teach sustainability to engineering students. The students also agreed that it was necessary for their engineering lecturers to attend the modules taught by their non-engineering lecturers and vice versa, to enable comprehensive discussions about sustainability issues and ideas with the undergraduate engineering students. The students also agreed that all common modules in the undergraduate engineering curriculum advance the need to apply knowledge that they learn in the classroom, to explain engineering issues or problems related to the environment. It was also found that the English and Communication modules content and lecturers were the least to teach engineering students to reflect upon issues and new ideas they had learnt from real environmental problems, in comparison to the Engineering, Management and Social Science and Humanities modules content and lecturers.

The results of the role of the common modules in enabling undergraduate engineering students to reflect upon issues and new ideas they had learnt from real environmental problems from the perspective of a future engineer also denote that the Engineering module content and lecturers were the most to provide such input. The least to do so were the English Language and Communication module content and lecturers. These findings therefore imply that the English Language and Communication modules seem to pay less attention to the reflection of issues and ideas from real environmental problems from the human and future engineer points of view.

The results on the extent of the use of ESD approaches for teaching and learning within the undergraduate engineering programme suggest that students from different engineering programmes are provided the opportunity to reflect on activities collaboratively as a group. Learning approaches in the university, however, were not focused upon experiences students gained from their direct involvement in learning experiences involving environmental issues. Students however agreed that learning approaches in the university encouraged them to apply ideas they have learnt and experienced through real world learning situations involving environmental issues. Students also agreed that they were encouraged to be responsible for their own learning of environmental related issues.

Students' views were also gauged to ascertain their level of awareness of the presence the 30 competences in the curriculum of the undergraduate engineering programme. Given that the mean scores of all 30 competences recorded values of 3.78 and above, it can thus be suggested that students believe that the 30 competences were indeed part of the present undergraduate engineering programme curriculum. The top two sustainable development competences students thought their undergraduate engineering curriculum was preparing them for were *Understand how science and technology has changed nature and people's effect to the environment* and *Appreciation that current actions can impact on the quality of life of future generations* which both recorded a mean score of 4.28 respectively. The competences *Able to participate in groups consisting individuals from many fields or disciplines of study to jointly evaluate causes, put forward and work out problems, and provide solutions to problems* and *Consider implications of engineering processes in relation to the environment* also recorded identical mean scores with a value of 4.24, making these two competences the second highest competences students thought the undergraduate engineering curriculum was helping them develop.

The item *Understand how cultural and social values influence how resources are viewed* recorded the lowest mean score of the 30 competences, with a value of 3.78. This was followed by *Apply business and management skills to solve real life sustainability problems facing society* and *Apply social science and humanities concerns to solve real life sustainability problems facing society* with mean score values of 3.81 and 3.82 respectively. This suggests that students were of the opinion that these were the competences with the least presence in the undergraduate engineering curriculum.

5.3 Key findings of interview on the pedagogical and institutional approaches presently engaged

Interviews were conducted with the university's academicians, members of the university management, engineering industry practitioners and final year undergraduate engineering students to explore their views on the extent to which sustainable development is presently included in the undergraduate engineering curriculum from pedagogical and institutional angles. The findings and its evidence are discussed below.

Sustainable development in the present undergraduate engineering curriculum

Academicians were interviewed to explore their perspectives on the extent to which they thought sustainable development was incorporated within the modules they taught in the undergraduate engineering programme. Although students' views on this issue were obtained via the survey, interviews were conducted to explore this issue in further detail. The interview revealed interesting contrasts in views presented by the academicians and students.

Most of the non-engineering academicians revealed in the interviews that sustainable development content was not incorporated in the modules they taught. A6, who taught the Engineering Economics module explained that he did not include any content or examples related to sustainable development in his module as it did not did have any direct relationship to the module. He also said that he was unsure of the extent to which sustainable development was incorporated within the undergraduate engineering curriculum.

A7, who teaches the Introduction to Management module, also revealed that it did not contain any learning outcomes related to sustainable development. She reasoned that it was difficult to include such content in her module when the roles of non-engineering academicians in respect to their contribution to the university's sustainable development agenda were not clearly defined by the university.

> *I think I can echo to you that I'm still unclear to where we stand in contributing to sustainable development agenda of the*

> *university and therefore it's difficult for us to in put things in place especially in teaching the students.*
>
> (A7, lines 27-29)

A7 also explained that there is yet to be a directive provided by the department head for sustainable development to be included as learning outcomes in common modules offered by the Department of Management and Humanities. There was also no compulsion from the Business and Management unit head for all academicians teaching these modules to include sustainable development within the contents of the module. A7 stated that there was however a need for academicians in the department to orient their research towards sustainability, through membership in a sustainable development based research group established by the university.

A9, a junior lecturer who teaches and coordinates the Islamic Studies common module, and heads the social science and humanities unit stated that she was unsure if sustainable development was discussed within all modules offered by this unit. However, she mentioned that it may be indirectly addressed. When probed further if it was included as learning outcomes of these modules, she replied that it was not.

> *A9:* *We have Malaysian studies, Islamic studies, Moral studies right, psychology, of indirectly... maybe if you want to know direct...relationship and direct relation. I don't know, I need to do survey first lah so I can give you answer the fact*
>
> *I:* *Alright, just a generally, a general thing, do you see any? Just the learning outcomes. Anything?*
>
> *A9:* *None.*
>
> (A9, lines 360-369)

It was interesting however to find that A9 had appropriately identified lecture topics in the Islamic Studies module she taught, which were related to environmental, societal and scientific issues earlier on in the interview. One of the environmental issues discussed involved the discussion of water and Islam.

> *I did ask them to find the Quranic verse that related for example, water and everything, that's it lah maybe not very practical but just theory they know there are in the Quran there are the Quranic verse about environment, and how their responsibility in taking care of the environment*
>
> (A9, lines 253-258)

She later contradicted her own statement (lines 360-369) when she said that sustainable development was indirectly covered in all the social science and humanities modules, signalling her unawareness of the importance she has placed on sustainability within her own module.

> *I:* *Okay, any of the topics involve how the religion has some connection with the environment, with the society ...or other topics*
>
> *A9:* *Yes, yes yes yes. Environment, society, science development... individual interest and everything*
>
> (A9, lines 193-202)

In respect to the inclusion of ESD approaches to teaching and learning, the interview with A9 indicated that critical and reflective thinking were encouraged in her module, and was also made a component in her assessment of student projects. Ironically, she was not aware that the teaching and assessment approach she used in teaching these modules was related to ESD, and only came to realize this when I explained it to her after the interview session was over. A11, who teaches Moral Studies, seemed more aware of the presence of sustainable development content in his module. A11, who teaches Moral Studies, a module categorised as a social science and humanities module, said that he encouraged his students to think critically and reflectively. He further stated that his module also encouraged students to conduct self-analysis of their selves and to be self-reflective *That is the whole thing in the project, they have to do self-analysis and self-evaluation* (A11, 1351-1358). Charitable projects were also organized as part of teaching and learning approach in his module.

Interviews conducted with engineering academicians revealed the various ways in which the different undergraduate engineering programmes approached the inclusion of sustainable development within the curriculum. The Engineers in Society common module offered by the Civil Engineering programme for instance, does not focus much on environmental, economic or societal issues related to sustainable development, said A4, a senior lecturer from the department, who also teaches and coordinates this module. However, he tries to relate human dimension and values through the ethics topic in the module. Due to the large class size and limited time frame, A4 takes a conventional approach to teaching the Engineers in Society module.

> *And in terms of teaching approach, first and foremost I would look at the numbers, because if you have a course like Engineers in Society, where where it is a mass so, of course it is impossible for you yes, for you to a little more innovative, for instance, because of the head counts the somehow the delivery is still conventional.* (A4, 211-215)

He also explained that opportunities to include real life engineering problems were not possible.

> *I:* *Yeah, okay, do you do engineering projects within the community? To solve real problems you know, through EIS?*
> *A4:* *No.*
> *I:* *No*
> *A4:* *We don't have time for it.*
> (A4, lines 350-357)

It was also interesting to find that the Civil Engineering programme was appointed by the university to be the custodian of all sustainable development modules offered at the undergraduate level. While sustainable development was a programme educational outcome of the Mechanical Engineering programme emphasis was not placed by academicians to include sustainable development content within the learning outcomes of the modules they teach. A3 said that she does not include sustainability related learning outcomes in the modules she teaches and coordinates, but mentions it briefly when she has the chance to do so during lectures. She was however unsure if students understood what she had briefly discussed with them. Her primary concern was that she had carried out her responsibilities as an academician by relating the topic of her lecture to sustainable development *And don't know whether they understand or not but I have done my part which is to tell them that there is this new thing that sustain, because I think because feed in tariff is related to renewable energy* (A3, lines 41-47).

A3 also mentioned that time was an important factor in determining if she could include real world engineering issues in the modules she teaches. She cited the tri-semester system as a hindrance to this inclusion.

> *...real problem was...it was practised last time, but now the 3 semesters 3 trimester thing comes in, first thing, students they are overloaded and lecturers also we do not have so much time ... so we just give them a simple problem which is not from the industry, because we need time to mark.*
>
> (A3, lines 209-212)

In the Chemical Engineering programme, A1 estimated that only 20% of the modules offered were sustainable development related.

> *I would say only about 20% the courses under chemical engineering will talk about something like sustainability but other courses which are... are too technical ... too confined to certain areas they don't go to the the the... broader spectrum of talking the the..talking about the.. the.... the wholeness of the whole problem.*
>
> (A1, lines 41-45)

A10, a senior lecturer in the Electrical and Electronics Engineering programme stated that he subtly hints upon sustainable development in the modules he teaches, instead of making obvious reference to the concept. He also stated that sustainability in the Electrical and Electronics Engineering programme may not necessarily be approached from environmental or societal dimensions, but from a design perspective, i.e. in terms of sustainable design approaches.

> *whatever that they do and whatever they learn they will eventually cooperate all the different things that they have learnt from different features that they've built to their final project, so that's how we look at as sustainable design in that sense, but we got to cover all the other things like environment and all, mine is based on electronics so it's very small, really can't address those bigger issues kind of thing*
>
> (A10, lines 101-106)

Final year undergraduate engineering programme students revealed many interesting, yet surprising revelations on the approaches employed by their lecturers in delivering sustainable development. S4 from the Electrical and Electronics Engineering programme for example described his lecturers as not taking sustainable development seriously.

> *like everyone who teaches the technical side of this, if it's an engineering course, so he will only be concern of the technical side of the course, it's all related to numbers, equations and what not, and when it comes to non-management courses, I'm sorry to say this, but people don't take it very seriously*

(S4, lines 104-107)

S2, from the Mechanical Engineering programme said that sustainable development issues were mostly dealt through adjunct lectures instead of formal lectures in her programme. S5, who is from the Chemical Engineering programme, explained that her lecturers did not relate their module content to sustainable development. S1, who is from the Petroleum Engineering programme, echoed similar sentiments expressed by S5, also said that his lecturers did not make the relevant connections to sustainability in the modules they taught. This was apparent when he said, *Yes. They didn't mention anything about that* (S1, lines 136-143). He also explained that lecturers did not relate the university's green initiatives to the modules they taught. S2 went on further to comment that there should be more interaction and communication between the lecturers and students.

I: *What about the teaching, aspects of teaching, like you said just now a lot of greenery non-smoking zone do your lecturers pick up what they are doing in the university, do they include that in the class, do they make the connection*

S01: *No. No such thing.* (S2, lines 219-232)

S2 also explained that the non-engineering academicians were more effective lecturers than the engineering academicians. He went on further to reveal that students were given little opportunity to present ideas or question their engineering lecturers. He also found that engineering academicians who joined academia with prior industry experience were not open to receiving comments or objections from students in comparison to academicians without industry working experience, i.e. *Okay, say like that all the non-engineering lecturers ... they can taught, teach very well...the one that coming from the industry, they're not open to any discussion or something, if we are trying to oppose their idea, they think we are trying to reject their idea* (S1, lines 266-272).

S1 also commented that engineering and non-engineering academicians never discussed how sustainable development would impact upon students' futures, their engineering careers and society. Said S1, *Because we students we didn't see what are the SD what are the purpose to know about these things, how are* *this things going to affect our future, out career our society* (S1, lines 287-289). S3, a student from the Civil Engineering programme said that sustainable development was not a topic she found in lectures or learning materials provided by the academicians in her programme. It was also not formally approached through coursework. However, she has heard it being mentioned in passing by lecturers whose research work was sustainability related or had prior industry experience related to sustainable development.

Unsustainable learning practices

The interviews revealed fascinating views from academicians, members of the university management and final year undergraduate engineering students on learning issues within the undergraduate engineering programme at the university that has been deemed unsustainable. These include students' attitudes towards sustainable development and other problems associated with learning, i.e. the inability to think critically, the inability to relate to the module being taught, being too dependent on the lecturer and not being proficient in the English language.

Interviews with academicians and members of the university management revealed unsustainable learning practices that were taking place within the undergraduate engineering programme. One of these unsustainable learning practices concerned students' attitude towards sustainability, which cut across academic and non-academic quarters of their learning experiences at the university. From an academic perspective, A5 explained that students she taught showed little concern for issues concerning sustainable development. A5 mentioned an example of students questioning her on the relevance of them having to be concerned about animals in the Professional Communication Skills module. She said *this students they were like ma'am why do we have to be concern about the animals* (A5, line 39).

Echoing similar sentiments on students' attitude towards being sustainable was U3, a member of the university management. U3 was saddened by the fact that students failed to project sustainable attitudes at the university. He cited the issue of littering in lecture halls as an instance of students negligent attitude towards sustainability in the university. Other academicians however were more concerned with the undergraduate engineering students' attitude towards learning in general. The importance for students to think critically was a learning issue brought up by many of the interview respondents. This issue was seen as an issue that needed much attention, as it had an impact upon other learning practices, such as the students ability to express themselves in English and their ability to relate to the modules they were taught. A3, a junior engineering academician, who is also the coordinator of the engineering team project module offered in the Mechanical engineering programme, feels that students need to be motivated to think critically. She explained that she indirectly leads her students into thinking about an issue from various perspectives when she teaches her module, *I didn't tell them that you have to use critical thinking, I didn't say the word critical, I will just ask them, what do you think if you're having... if this one is changed, if that one is changed.. ... what is going to happen? That is the whole thing in the project, they have to do self-analysis and self-evaluation* (A11, 1351-1358) she said. She however revealed that her efforts are not very successful, as most students prefer to keep quiet, with the exception of a student or two who would express his or her thoughts. She also stated that international students tended to ask her more questions in class, in comparison to their Malaysian counterparts.

A9, a junior social science and humanities module lecturer faces similar situations during her lectures. She explained that the international students were more *vocal* in comparison to the Malaysian students who attended her Islamic Studies module. Interestingly, when students were asked why they did not actively engage with their lecturers, S2, a final year undergraduate engineering student explained that it could be due to shyness, not wanting to interrupt the lecturer, not being able to comprehend the content of the lecture and not wanting extra tasks assigned to them.

> *Maybe because they don't really get what he is teaching maybe they shy maybe they don't want to interrupt the lecturer they want to see they want to let him finish first...Or sometimes when we ask, some lecturers say Okay that's your assignment. So maybe that's the reason.*
>
> (S3, lines 418-426)

Another instance of students' inability to think critically was provided by A10, a senior academician teaching engineering modules. He stated that students were unable to make the connection between what they had learnt in previous semesters, with what they were learning in the present semester. *They don't think that the previous knowledge you know in another course is related to this course also , you can utilise whatever knowledge you found from that, you can utilise here, ... yeah, they don't make the connection found from that* (A10, lines 349-352), he exclaimed.

While A10 commented on students inability to relate between previous and present modules they were taking in the undergraduate engineering programme, U3 on the other hand expressed his concern over the students' inability to relate their modules to sustainable development. U3 explained that students may not be able to make the sustainable development connection to their modules simply because the term was not described in the module in an obvious manner. As a result, students could be of the perspective that the module they had taken, or were presently taking was not sustainability related. U3 attributed this setback to the spoon-feeding culture in the Malaysian primary and secondary education system, which he described as an unsustainable and flawed approach to learning at the university level. U2, a senior member of the university's management attributed the students' inability to relate, to their act of compartmentalizing their thoughts. This act, in turn, makes them unable to connect thinking to action, and relate from one issue to the other. He also pointed out the need to make the undergraduate engineering curriculum relevant to the lives of the students so they would be able to relate to the modules offered more effectively.

Surprisingly, A6, a senior academician teaching management modules to undergraduate engineering students had a contradictory explanation of the critical thinking issue. He explained that due to the fact that students who enrolled in the university were the best amongst their peers, he expected them to be already able to think in a critical manner. He found that students had the ability to think critically, but lacked the ability to think in a conscious manner.

He said, *I think they should be* (critical thinkers) *because they are good students, ya the thing is whether they can think consciously or not* (A6, lines 209-210).

English serves as the medium of instruction in the university. Unfortunately, the interviews revealed that Malaysian students lacked proficiency in the language. A6 expressed his disbelief at the level of proficiency of the Malaysian students. This English proficiency barrier not only made it difficult for the students to express their thoughts and ideas in English during the learning process, but also made them timid, says A6. This could also be one of the reasons A3 and A9 found their Malaysian students less expressive, in comparison to their international students. He noted, *bila kita buat East coast lah, Kelantan, Kelantan, Terengganu, the English teruk also tapi bila tanya, English dapat A, tapi teruk tak boleh cakap o.. so I said you mix lah , you cakap mix lah, I just wana see whether you can bring idea or not* (A6, lines 265-268). Translation: Students from the East Coast regions of Malaysia and Kelantan, have a poor command of the English language, but when you ask them what they scored for English (in their secondary level national English examinations) they would say they scored an A. But it's terrible. They can't speak fluently in English. So I tell them to mix the Malay language and English language, to see if they can express their ideas to me.

Undergraduate research assessment

The interviews also point to the need to look into the inclusion of sustainable development within research assessment exercises in the undergraduate engineering curriculum in the university, as it was not the current practice to do so. Four assessment components were identified by interviewees as potential channels in which a sustainable development assessment component would be seen as beneficial. These were the Final Year Project, the Final Year Design Project, the Engineering Team Project and Engineering Design and Exhibition competition.

IP4, an engineering consultant who was interviewed, explained that the addition of a sustainable development assessment component in the university's Final Year Project and Engineering Team Project would be a beneficial move. He however cautioned that more thought should be put into the manner in which the assessments would be carried out. He said, *Great, I think I think that is good, when you talk about ETP and FYP bringing the component in as one of the marking scheme that will work...what do you mean by sustainability, so you must break up the components*

(IP4, lines 420-424)

In discussing the issue of a sustainable development assessment component within research projects undertaken by final year undergraduate engineering students, A1 explained that there were no such assessment components in the Final Year Project and the Final Year Design Project at present. Surprisingly however, S4, a student who has taken part in the Engineering Design and Exhibition competition, explained that while sustainable development based assessment components were not included as any of the objectives of this research competition, entries that incorporated elements of sustainability were guaranteed a medal, even if the model they developed was not fully functional. This revelation by S4 suggests the presence of inconsistencies within undergraduate student research assessment practices in the university. There also seems to be an indication of the element of selectivity in approaching the inclusion of sustainable development as an assessment component within engineering research projects carried out the undergraduate level. As evident from the issues revealed by A1 and S4, emphasis on sustainable development assessment seems be placed in engineering competitions, instead of final year projects which make up essential modules in the undergraduate engineering programme curriculum.

Sustainable development content within Language & Communication modules

Interview responses received from academicians and final year undergraduate engineering students revealed interesting findings with regards to the inclusion of sustainable development and ESD within the Language and Communication modules. These include the challenges faced in embedding sustainable development content in Language and Communication modules, the existence of sustainable development content within these modules as well as teaching and assessment of sustainable development content. Interviews revealed that the inclusion of sustainable development content within Language and Communication modules was a challenge for the academicians teaching these modules. An academician with 5 years experience teaching and convening Language and Communication modules, specifically Professional Communication Skills and Academic Writing at the undergraduate level revealed that the inclusion of sustainable development content in these modules were not as easy as embedding such content it in a management or etiquette related module. She explained the following: *if I were to teach etiquettes... managements perhaps, I can at least talk about these things to them to them but somehow when we teach language and communication we can't really put that in the module itself* (A5, lines 28-38).

Confirming her views were three final year undergraduate engineering students, S4, S2 and S1, who had completed these modules. All three students agreed that there was no discussion of sustainable development in the Professional Communication Skills and Academic Writing modules, as the focus of these modules were to develop students writing and presentation skills. S4, for example had this to say about the issue: *not really. Again, it was only for academic writing, the main objective was to write summaries, to write reports, just to produce the 4-5 outcomes the university listed for them (lines* 295 – 322).

While A5 maintains that it is difficult to include sustainable development content in the Language and Communication modules, she explained that she tries to approach the teaching of these modules using the group discussion method during her sessions in class. However, she admitted that this approach is not very effective, given the fact that students tend to group amongst their own engineering programmes to be within their comfort zones, instead of forming mixed groups consisting students of the various engineering programmes in the university. She also cited problems students faced in conducting mixed group discussions or projects after class hour. Besides the group discussion approach, A5 also admitted to not using other ESD based approaches such as case studies or community based real problem solving activities in the Language and Communication modules she teaches. She also stated that sustainable development was not a component that was assessed in these modules.

Sustainable development and Malaysian higher education

The interviews also point to the various issues that could impede the inclusion of sustainable development within the university's undergraduate engineering curriculum, many of which are a result of the manner in which the Malaysian higher education system operates. U3 for instance mentioned that the present undergraduate engineering education system in Malaysia was unsustainable. He commented that even though the outcome based education system was moving away from being too exam oriented, it was in fact creating an adverse consequence on the students' academic wellbeing, given the requirements it posed on undergraduate engineering programmes to assess multiple domains of learning, i.e. their knowledge, skills and attitude. This form of assessment, states U3, is burdensome for the students, and is unsustainable in practice, as it does not truly address the essence of sustainability and the manner in which it relates to the students' lives.

> *we are actually driving the students up the wall and pushing them to become more academical than ever, then they said that oh why they are not performing... why they are not doing this, why they cannot fit in, why they cannot work you know, because they have not been taught the actual, what they call that, meaning of this sustainability , in their lives , how they gonna use the education to lead their lives , you see not just go out there and become machines*
>
> (U3, lines 418-423)

Commenting on yet another unsustainable Malaysian higher education practice was A5. She explained that the tri-semester system that was introduced in the university to emulate a similar practice in Malaysian public universities posed operational problems for teaching. One if these problems were the difficulty faced in replacing classes that had to be cancelled. This situation inadvertently allowed room for manipulation. She said, *Especially now when we have the tri semester, it so difficult even to get replacement class there's a time called replacement class I have to consider all this things otherwise they will give me million and one excuses* (A5, lines 334-337).

While U3 and A5 commented on the flaws in the present undergraduate engineering education system, as well as the operational problems the university faced with the introduction of the tri-semester system, A1 and A11 on the other hand were concerned about the manner in which the university introduced sustainable development within the undergraduate engineering curriculum. A1, an international staff, and associate professor from the Chemical Engineering programme talked about the need for the undergraduate chemical engineering programme curriculum to consider the long term and short terms goals of sustainable development, S*o sustainability is looked into two different perspectives on a long term basis or a short term basis ... but I'm I'm not sure in chemical engineering there are many many courses who discuss on the sustainability issue on a very long term basis* (A1, lines 30-34). A11, also an international staff and senior lecturer from the Department of Management and Humanities was of the opinion that it was not necessary to include the term 'sustainable development' in the curriculum, as it was supposed to be understood. He also commented on the need for the university to move towards the inclusion of sustainable development in the curriculum within a broader context that was also long term focused.

Institutional Approach to sustainable development

The *Institutional Approach to sustainable development* sub-issue looked into the university's overall approach to sustainable development. Five themes emerged from the analysis. Interview respondents included academicians, university management, ESD experts and final year undergraduate engineering students.

Sustainable development in light of the Research University agenda

The interviews revealed the rationale of the university's identification of sustainable development as an approach to the institution's research agenda, and its impact on the university's aim of being accorded research university status. A8, a senior lecturer teaching in the management unit, expressed dissatisfaction over the university's move to intensify sustainable development based research. She opined that that the university was research obsessed as a result of trying to achieve research university statues and failed to recognize other pertinent factors in driving sustainable development within the university. She explained that sustainable development was not only about research, but also about teaching, cultivating a sustainable state of mind as well as making it a culture within the institution. She believed that such obsession was not conducive for a university. She said, *they think that as part of knowledge, to teach the kids and finding part of research lah which this university is so obsessed with in order to turn it into a research university to me is is more than that...it's about mentality it's a culture by itself.*

(A8, lines 276-280)

A senior member of the university's management however revealed that the university had chosen sustainable development as its overarching research theme to be in line with the environment and the wellbeing of the society and the future generation. He said, *that's why we make sure that sustainability development is the core of our aah mission oriented research. So that whatever that we do aah, it will be able to sustain the future of our generation and also not jeopardize aah whatever we have today* (U2, lines 50-55).

Top management's role in cultivating sustainable development culture

Interviews also highlighted engineering and non-engineering academicians' views on the role played by the university's management in nurturing a culture of sustainability in the university. A8, a senior non-engineering academician who was saddened with the manner in which research KPIs were imposed upon academicians, acknowledged that the university's decisions were influenced by Malaysian higher education policies. She urged the management to be equally supportive of teaching, as they were of research, as the culture of sustainability in universities was equally dependant on teaching, as it was on research. She noted, *we have KPIs to accomplish so management... is basically imposing on all of us to achieve the KPIs because the government wants it that way ... we cannot sacrifice the teaching part you know that also ensure sustainability* (A8, lines 42-53).

As the university is the education arm of one of the country's corporate conglomerate, A11, a senior non-engineering academician urged the university to address the corporate vs. educational conflict the university was embattled within, to nurture and promote sustainability in the university. While the non-engineering academicians perspectives were more focused upon their professional well-being and the university's corporate vs. educational divergence, A2, an associate professor from the engineering faculty was more concerned about the need to address the management's commitment to sustainable development, as he observed that the management did not seem committed enough in cultivating the culture of sustainability.

> *I I think the the only way is to influence the top management. the top management have to put their foot down, commitment you know, it is the top management that is 'okay we'll do it' but but it's not seen to be involved you know, I think the top management has to be seen that they are also part of it they are involved*
>
> (A2, lines 243-246)

He suggested for sustainable development to be made a priority agenda in top management meetings and issues concerning sustainability to be communicated to the university community as a whole through the university deans and heads of departments. This he said was unfortunately not the current practice at the university.

Improvements for the cultivation of sustainable development culture

Findings on improvements for the cultivation of a sustainability culture in the university revealed interesting perspectives. A2 for instance asserted the need for all sustainable development initiatives organized by the university to be monitored on monthly or weekly basis. A4 explained the need to look into the tri-semester system. He explained that the tri-semester system the university was problematic, as it had an impact on the manner in which modules were structured and learning was approached. EP3 on the other hand noted that the campus should provide the environment for thinking in terms of sustainability, which it presently does not do. He said, *in terms of consciousness I'm quite ambivalent because I think again the campus does not provide that that environment, that structured environment to thinking in sustainability* (EP3, lines 314-316).

Students however were more concerned on the level of communication between the students, the university management and academicians on matters pertaining sustainability in the campus. S1 said that the university did not communicate sustainable development initiatives undertaken on campus.

> *Okay I think the key issue, the most important thing, is the communication between the management the lecturer and students itself. Because we students we didn't see what are the SD what are the purpose to know about these things, how are this things going to affect our future, out career out society*
>
> (S1, lines 286-289)

Misassumptions on the role & position of Management & Humanities department

Findings of the sub-issue on institutional approach to sustainable development also revealed a theme on the misassumptions on the role and position of the Department of Management and Humanities, of which the university's non-engineering academicians (language and communication lecturers, business and management lecturers, social science and humanities lecturers) are a part of. The interviews indicate that the non-engineering academicians were of the view that the university and the engineering academicians misunderstood the role of the non-engineering academicians in driving the sustainable research focus of the university.

A4, an engineering academician agreed that there was an assumption in the university which viewed engineering and sciences more prominently then they did the language and communication, management, social science and humanities based research. He noted that the development of a proper mechanism to counter these misperceptions may encourage more collaborative research between the engineering academicians and their non-engineering counterparts. A5 a non-engineering academician nevertheless noted that there was a conflict between engineering and non-engineering academicians in interpreting sustainable development based research. Echoing similar thoughts was another non-engineering academician, A8, who explained that the university's mission oriented research was *just too rigid and the technical people they do not speak the same language as us* (A8, line 71). She went on further to comment that engineering academicians and non-engineering academicians viewed sustainable development research differently.

EP3 a professor and also a non-engineering academician asserted that engineering academicians assumed that all non-engineering academicians would be able to sustain the social dimension of a sustainability related research. EP3 further explained that the engineering academicians failed to understand that the social science and sustainable development dimensions was the bigger picture of which the engineering dimension was a part of.

> *the thinking I discovered is they think that social science humanities and the sustainability dimension is part of engineering. okay and therefore they assume that everybody in the department perhaps everybody in the world who falls under social human sciences would be able to sustain social science dimension research so they think we are small part fitting into the hole but they are around. The social sciences and the sustainability dimension is the larger part where engineering is a part. So the hole cannot fit into the part cannot fir into the hole so they have got the thinking in error.*
>
> (EP3, lines 124-131)

Sustainable development and the engineering curriculum

This theme looks into the extent of the university's policies and its impact on sustainable development and the undergraduate engineering programme. A3 revealed that the university was selective in its emphasis of its policies for the inclusion of sustainable development. A3 commented that emphasis was presently placed upon the inclusion of sustainable development within research, and not within teaching and learning practice. A4 revealed that teaching practices in the university was still very much one way and teacher-centered. He also stated that although the outcome based education approach seemed to be put in place, it was nevertheless for accreditation purposes. He also stated that the problem based teaching and learning practices espoused by the outcome based education approach were not enforced in totality in the university. U4 explained that the university had not made it a necessity for sustainable development to be made an explicit learning outcome for all non-engineering modules. He noted, *I know engineering programs they have explicitly mention* *sustainable. For this department, you may have it for some courses you may not have it, but you may state it* (U4, lines 55-57).

U2 explained that sustainable development was not of high importance across the board in the undergraduate curriculum and university policies. He asserted the need for an all-encompassing sustainable development statement for the university to make it clear that the university was serious about sustainable development in terms of its overall policies and practices.

> *I have to admit that, for the time being it is not of high importance, currently even though we do talk about it but it is not agenda that ahh, seem to be of utmost importance for the time being..it is projected in a subtly, in many other forms...maybe what the management should do is to put it across in a more concrete manner...even coming up with a statement on sustainability development as what we have done for HSE, for example but we have said it across the board, we have on HSE policy which clearly state... the importance of conserving energy, importance of ... nurturing environment and also pollution. That is already being stated..however, we need to put against more clearly to ensure we are moving on this agenda*
>
> (U2, lines 129-138)

EP3 explained that the university has been rather hostile to people and societal dimensions, which in turn has reflected badly on the undergraduate engineering programme. He said, *generally I would say that the engineering curriculum has not taken to count has not taken to count the tangible dimensions has been quite hostile to people and society entomologically as well as ontologically and this does not work well for the future of the curriculum* (EP3, lines 51-54).

Interestingly also, S1 explained that his encounters with sustainable development were not obtained from his university experiences but through his own initiative. S2 however estimated 30% of her university experience to be sustainability related.

> *I:* *Over your years of study here, do you think the university as a whole ….provides a conducive environment for sustainable development or not, being nurtured. The management, the lecturers, the support staff.*
>
> *S2:* *Maybe 30% la*
>
> *I:* *30%*

S2: *It's not like exactly what they are doing it's just like part of their teaching job they just like giving us some like little bit of those things you know*

(S2, lines 360-369)

5.4 Discussion of key findings

The findings highlighted in the sections above point to several pertinent issues in relation to the extent to which sustainable development and ESD is incorporated within the undergraduate engineering curriculum of the university. The discussion of these findings will be approached from two perspectives, namely curriculum and practice.

Curriculum

From the perspective of the undergraduate engineering curriculum, it appears that sustainable development and ESD do not feature prominently within the institution's academic and research vision and mission. Undergraduate programme outcomes indicate a moderate increase in the former and modified programme outcomes related to sustainable development competences. Findings on the extent of the inclusion of sustainable development and ESD learning outcomes of common undergraduate modules also suggest that emphasis of these outcomes could be improved as presently 40% of the common modules have learning outcomes related to sustainable development and ESD. Although it appears that the university has to intensify its endeavours to make sustainable development and ESD more prominent within its undergraduate engineering curriculum, these low percentages nevertheless indicate that the university is moving towards the goal of advancing sustainable attitudes amongst its student stakeholders through its undergraduate engineering curriculum. This realization is in line with the findings of the study conducted by Leal Filho (2009) on the significant role played by a university in instilling positive attitudes towards the environment for its stakeholders.

In terms of sustainable development being made a learning context within the undergraduate modules, the findings of the study suggest that it does not feature within 90% of the common modules offered at the undergraduate engineering level at the university, with none of the common non-engineering modules having learning outcomes related to sustainability. Surprisingly though, interviews with academicians indicated that there was a need for sustainable development to be discussed within a broader context, with allowance for short and long term goals to be specified clearly, a requirement which the present undergraduate engineering modules lacked to emphasise. These findings are similar to the findings of studies conducted by Bryce et al (2004), Valazquez et al (2006) and Mulder and Jansen (2006) which all found a narrow curriculum to be a hurdle to the implementation of sustainable development within the undergraduate engineering curriculum. However, there were also contradictory interview findings, where it was found that not all academicians were in favour of this move, as it was believed that there was a need for a strong discipline centric focus for development of the undergraduate modules.

Besides this, it was also found that sustainable development was not a learning outcome or assessment component of undergraduate research modules offered within the undergraduate engineering curriculum. Surprisingly, research projects submitted for engineering competitions organized by the university were guaranteed an award, in comparison to competition entries which lacked a sustainable slant. These selective measures in assessing undergraduate research suggest the presence of inconsistencies in academic policies and regulations related to the inclusion and assessment of sustainable development within the undergraduate engineering curriculum.

There was also a perception amongst the final year undergraduate engineering students that the undergraduate engineering modules at present paid more emphasis on the understanding of the impact of science and technology and human kind to the environment and to the future generation. Emphasis was however paid least in terms of comprehending the role of culture, and social values, and the application of business and management skills and social science and humanities concerns within the curriculum. These findings are in contradiction with the views of the non-engineering academicians who claimed to include discussions on environmental and societal issues through religious and values based modules offered within the undergraduate engineering curriculum. It was also found from academicians that there were limited opportunities to include real life problem solving approaches within the curriculum due to large class sizes.

Practice

While there seem to be attempts to use teaching and learning approaches related to ESD within the undergraduate engineering modules, i.e. the use collaborative and active learning strategies, case studies, problem solving, individual activities and group based activities, the interview findings however indicate that these activities have not been approached within an ESD pedagogical framework in mind, or with the aim of developing sustainability competences within the undergraduate engineering students. Interviews also found that these pedagogical strategies have its limitations, as apparent in the Professional Communication Skills module. It was found that academicians who do engage engineering students in group discussions often found this approach futile, as students would rather form groups amongst those from the same engineering programme, rather than be in groups which consist of students from the various engineering programmes in the university. Fear of breaking out of comfort zones and timetable inflexibility were cited as some of the reasons for engineering students to group amongst the same engineering programme.

In addition to the use of collaborative and active learning, case studies, problem solving, individual and group based activities, the survey and interview findings also revealed that reflective activities of real environmental problems were the least practiced by English and Communication academicians and modules. Interestingly, this group of academicians was also found to be the least to relate sustainability issues within the context of the engineering workplace. Even so, student interviews revealed that both engineering and non-engineering academicians were equally responsible for not discussing the manner in which sustainable development would impact upon the students future careers. This therefore suggests that both engineering and non-engineering academicians have a more significant role to play in relating sustainability to the engineering workplace.

Final year undergraduate engineering students also believed that it was only their Engineering and Management academicians who seemed to be teaching the undergraduate engineering students of the need to practice sustainability. Social Science and Humanities academicians carried out such discussions within a very limited scope, while English Language and Communication academicians rarely had discussions of such nature. These findings are in tandem with the findings from interviews conducted with English Language and Communication academicians and final year undergraduate engineering students as well. Nevertheless, interviews with the final year undergraduate engineering students revealed contradictions. Student interviews suggest that engineering academicians were equally responsible for not relating sustainable development to the modules they taught. These findings were once again in tandem with the findings of the interviews with the non-engineering academicians, who revealed that they did not include content related to sustainable development within the common non-engineering modules due to reasons such as sustainable development having no direct relationship to the modules, being unsure of what sustainable development entailed and the lack of directive by the management to include sustainability related learning outcomes. Interestingly, findings similar to those in the present study were identically observed in the study conducted by Martin et al (2006).

Interviews additionally revealed the use of mechanistic approaches during teaching due to large class sizes and the over-crowded tri-semester system. An over-crowded curriculum was found to be a similar deterrent in embedding sustainable development within the higher education in the United Kingdom, in the study conducted by Martin et al (2006). Down's (2006) study also noted this constrain as an obstacle to implementing sustainable development. It was also found from the interviews that engineering academicians were less effective than the non-engineering academicians in their approach to teaching. Engineering academicians were also seen to be less of facilitators of the learning process, and discouraged students from being inquisitive. Differences were also apparent in the industry experienced engineering academicians' approach to teaching, in comparison to engineering academicians without industry experience, as interviews revealed that industry experienced engineering academicians were adverse to being challenged or by students. There was also little interactivity between students and academicians, as revealed through the interviews. It also appears that the students were in strong favour of their engineering and non-engineering lecturers sharing knowledge on best practices of teaching sustainable development and attending modules they respectively taught to promote wide-ranging discussions of sustainability within the common modules.

The interview findings further revealed the presence of unsustainable learning practices within the present undergraduate engineering curriculum which were a result of unsustainable educational praxes permeating primary, secondary and higher education. Instances of these unsustainable learning practices included students' undesirable attitudes towards sustainable development and their high level of dependence on academicians, given their poor command of the English language and their lack of ability to think critically and consciously. The Malaysian primary and secondary education system which fortified the spoon-feeding culture was cited as a possible reason for these unsustainable learning practices.

An additional concern that was seen as a potential barrier in advancing the inclusion of sustainable development within the undergraduate engineering curriculum was the outcome based educational philosophy and practice, under which all undergraduate engineering programmes in Malaysia are regulated within. The outcome based approach was seen to have an adverse consequence on the undergraduate engineering students' academic well-being, as interviews suggest this approach to be burdensome to students. The practice of the tri-semester system was also found to pose operational problems for the university, which inadvertently also allowed room for manipulation by students. The findings of the lack of proper educational regulations highlighted in the present study bear resemblance to the findings of the study carried out by Valazquez et al (2005), which also listed the lack of rigorous regulations as a potential threat to sustainable development initiatives in higher education institutions.

Several concerns come to fore when interpreting these findings from a whole systems and whole institution approach to ESD. As pointed out previously in the thesis, whole systems learning not only ‘seeks to see connections, relationships and interdependencies to view the whole instead of the parts, but also to understand the intervening in one part of the system can affect not only the other parts, but the whole system’ (UN DESD Monitoring and Evaluation Report, 2013: p.28). It is therefore necessary for sustainability to permeate within the institution’s operations, curriculum, pedagogy and community. However, when comparisons are made between these principles and the present scenario in University X, gaps are evident.

From an operational perspective, sustainable development and ESD do not feature prominently in the university’s core academic and research vision and mission. Sustainable development does pervade through the curriculum, but is not prominently emphasised. Pedagogically, attempts are made to approach the teaching and learning of sustainable development using methods aligned to the philosophies of transformative learning and ESD, but these too are selectively practiced by a portion of the teaching force at the university. The mismatch is apparent given the incongruity between the university’s core academic philosophy, its educational outcomes and its pedagogical stance to teaching and learning processes. These gaps do not conform to the whole systems ideology and are most certainly unsustainable.

The findings suggest that University X has taken steps to teach sustainable development concepts and encourage research on sustainable development issues, in tandem with the Rio 2012 action plans and United Nation’s Decade of ESD (2005-2014). However, the curriculum and practice of sustainable development does not form part of the core curriculum across all engineering disciplines offered in the university’s undergraduate engineering curriculum, as stipulated in the Rio 2012 action plan.

In relating these findings to the context of higher education and ESD, it can thus be concluded that University X, has at a rudimentary level, included sustainable development outcomes within the curriculum of the undergraduate engineering programme. This inclusion is however a result of the university's adherence to the accreditation guidelines stipulated by the Engineering Accreditation Council and not an initiative driven by the university's conscious effort to integrate sustainability in relation to the principles and practices of ESD. Findings of the present study suggest that the inclusion of sustainable development within the undergraduate curriculum has intensified as a result of adherence to accreditation policies set by the Engineering Accreditation Council. With 40% of its common undergraduate modules learning outcomes related to sustainable development, the university could do more to institutionalize sustainable development and ESD within its undergraduate engineering curriculum. There is also evidence of discipline bias, prescriptive content and cognitive learning approaches in the modules taught in the undergraduate engineering programme. These evidences point to a curriculum uncharacteristic of educational philosophies and practices that are transformative and sustainable in nature. University X is thus seen to espouse mechanistic and transmissive ideologies that go against the philosophy of ESD.

As it presently stands, the university is therefore within the stage of accommodation, where the teaching and learning of sustainable development is conducted for the purpose of education about sustainability. The stage of accommodation, as explained by Sterling (2001), fits within the dominant paradigm of intuitive knowing (ethos), rather than the intellectual knowledge or practical knowing paradigms. University X can therefore be categorised as a university which focuses on perceptual dimensions to sustainable education within its curriculum, and is orientalist in its focus upon sustainability. This is because the university places emphasis on education about sustainability, instead of education for, or as, sustainability, as it should be focusing upon, if it is to adapt a transformative, whole systems approach within its undergraduate engineering curriculum. From the perspective of practice, findings point to the use of ESD teaching and learning approaches such as case studies, problem solving activities and collaborative group discussions. There is nevertheless limited emphasis on the use of reflective and reflexive teaching and learning practices and real life problem solving approaches. Such practices are an indication of first order learning taking place in University X, given the current practice of content led teaching that advocates cognitive learning and the transfer of information that is transmissive in nature. This is a drawback, given the fact that such teaching and learning practices do not only promote learning that is not transformative amongst students, but also develops engineering students who are conformative, rather than those who are reformative or transformative.

As highlighted in the findings, many engineering academicians were found to be more comfortable using conventional teaching methods rather than transformative methods that promote the facilitation of learning. Such teaching approaches practiced by the university's academicians are an indication that they lack the pedagogical knowledge and competences to help students learn to be sustainable. These practices also suggest that the university's pedagogical philosophies and its views of learning and the learner are mechanistic and non-transformative. This is further evidence that the university's pedagogical philosophies and practices promote transmissive and mechanistic ideologies that do not conform to the transformative pedagogical practices essential for the development and advancement of sustainable development and ESD within the undergraduate engineering programme.

5.5 Conclusion

This chapter highlighted the findings of Research Question 1. Key findings were compared with existing research, and interpreted in accordance with the theoretical orientation of the study. Chapter 6 focuses on the discussion of Research Question 2.

CHAPTER 6
DISCUSSION OF FINDINGS

STAKEHOLDERS' PERSPECTIVES ON THE INCLUSION OF SUSTAINABLE DEVELOPMENT CONTENT WITHIN THE UNDERGRADUATE ENGINEERING CURRICULUM

6.0 Introduction

The second research question explored stakeholders' perspectives on the inclusion of sustainable development content within the undergraduate engineering curriculum. This question consisted of four sub-questions. Research question 2a is first discussed.

Research Question 2a

6.1 Key findings of student stakeholders survey on the importance of sustainability input as undergraduate students and for workplace responsibilities

The student stakeholders' survey results suggests that final year undergraduate engineering student respondents viewed sustainability input as important for their present identity as undergraduate engineering students as well as in becoming sustainability competent engineering graduates ready for entry into the engineering workforce. These findings suggest a strong importance for the presence and inclusion of sustainable development within higher education in Malaysia, specifically within the context of engineering education.

The sustainable development competence perceived by final year undergraduate engineering students to be most important in preparation for workplace responsibilities was competence 5. This was followed by competence 27 and competence 11. The forth most important competence perceived by students was competence 12, while the fifth most important was competence 2. The sustainable development competence students perceived to be the least important in preparation for workplace responsibilities was competence 6. This was followed by competence 15 and 18. Competence 14 and 19 were the two other competences students perceived as less important.

The top five sustainable development competences perceived by final year undergraduate engineering students to be most important suggests that students are indeed aware that they have a role to play in advancing sustainable development and sustainable engineering. Ironically though, they seem to perceive that only engineering skills are most important in solving real life sustainable development problems facing the community. Students seem to perceive that business and management skills, social science and humanities concerns, expression of personal responses to environmental and social issues, culture and values were not as important as technical sustainable engineering competences, in findings solutions to sustainability issues. It also appears that students do not favour reflexivity as they perceived the competence to express personal responses to environmental and social issues to be less important in preparation for their workplace responsibilities within the engineering industry.

6.2 Key findings of interview on stakeholders' perspectives on the inclusion of sustainable development content within the undergraduate engineering curriculum

Interviews were conducted to explore respondents' perspectives on the inclusion of sustainable development content within the undergraduate engineering curriculum. The findings and its evidence are discussed below.

Sustainability competences as a necessity for the engineering workplace

Evidence from interviews suggests that there are three factors that should be looked into when considering the inclusion of sustainable development content within the undergraduate engineering curriculum. These factors, i.e. the university, the workplace and family create diverse impacts on the inclusion of sustainable development content in the curriculum. There also appeared to be mixed reactions from academicians on the inclusion of sustainable development competences in the curriculum. A6, a non-engineering academician for instance expressed that he was not very familiar with the terms sustainable development and ESD. On the contrary, engineering academicians seemed to be more confident in their understanding of sustainable development. A2, for example explained that the curriculum should be designed to accommodate what sustainability entails.

> *I think the curriculum should be designed to be able for the students to understand what is sustainable all about and and how to design ...whatever building, highways or water treatment, waste water treatment to meet that that that sustainability of the the receiving environment you know*
>
> (A2, lines 49-52)

A10 on the other hand said it was important for the university to decide on its approach to interpreting sustainable development, i.e. through thinking, design or the environment. A4 was of the opinion that it was necessary to educate all stakeholders to accelerate sustainability buy in at the university.

> *I'm also saying that we the tight curriculum design taking care of for sustainable development issues, the by in is quicker I think I've forgotten who said this but I read it. its last week somebody is telling that you need... among the players or among the stake holders, you need to have them educated. in order to quickly get the buy in*
>
> (A4, lines 111-116)

Industry professionals however expressed concern on the level of knowledge Malaysian engineering graduates possessed in terms of sustainable development. IP2 commented that students at present failed to understand the value of sustainability.

> *they should know on awareness on sustainability you know. Yaah when they came out they know something. It's not you come and learn here. You start again...you understand, they should have "Ohh this is sustainability is", you know or not. What we can do to environment, what we can do to this impact. While they have the basic, when they come out then it will help them. You understand, as you say, I am an engineer.*
>
> (IP2, lines 685-692)

He also explained that students who attended industrial training in his company had no knowledge of sustainable development. To counter this problem, he explained that his company had to resort to conducting sustainability training on the job.

A5 and IP1 were interestingly in agreement that the students' family played an important role in making them more conscious towards sustainability. While A5 speculated that students' insensitivity towards sustainability was perhaps due to family upbringing, IP1 said that family and the university were equally accountable for nurturing sustainable development knowledge and values within students.

> *... that is not the responsibility of the institution , education institution system that comes from the family...so combine together that definitely makes him a more responsible person*
> (IP1, lines 77-86)

S1 and S3 were concerned that their engineering and non-engineering lecturers did not attempt to address the academic-workplace sustainability divide. Both final year undergraduate engineering students were of the opinion that academicians failed to discuss the manner in which sustainability would impact their engineering careers.

Interview evidence further revealed stakeholders' views on the importance of having awareness of sustainability. A4 for instance acknowledged the fact that the lack of consciousness towards sustainable development would not enable students to contribute more effectively at the workplace. Industry practitioners on the other hand, were very concerned about preparing engineering graduates to be sustainability competent. IP4 stated that sustainability competences would give engineering students an added advantage at the workplace. IP3 and IP6 also acknowledged the importance for engineering students to be exposed to sustainability competences. Noted IP 6, *The concern is really that you learn to learn. So in this case it's more that awareness about sustainability to make sure the students, they have the right attitude towards this when they start working* (IP6, lines 69-71).

IP2 explained that there was a close relationship between sustainable development and the engineering profession in Malaysia. As a result, he said that it would be necessary for sustainable development knowledge, skills and values to be imparted to engineering students at the university, which in turn will prepare them for sustainability responsibilities at the workplace.

S4 was of the opinion that exposure to sustainability competences *would give you* (the student) *a better look, a 360 degree look from the problem* (line 62) while S2 said such knowledge would help her protect the environment. S5's view is that exposure to sustainability competences would enable her to make good decisions. Similarly, S1 said that these competences would make him a better engineer, while S3 said it would make her more marketable. She said, *I think as I said maybe 5-10 years, where actually sustainability will be bigger, so knowledge in that area will be sort, and its more, I'll be more marketable* (S3, lines 94-95).

Application of sustainability competences as an engineer

IP2 explained that it was important to be able to understand and value sustainable development to be able to apply it. Said IP 2, *You know or not, sustainability is like that one. People need to have… know about it, value it then they can apply it* (IP2, lines 97-98). IP1 on the other hand was of the opinion that such competences could benefit the students in two ways, namely as a responsible citizen and as a responsible engineer. He was also of the view that sustainability should be incorporated in everything an engineer does. Final year undergraduate engineering students were also concerned about becoming sustainability competent as they found it beneficial for their careers. S3 for instance aid that she would use her knowledge of sustainable development in the production and construction process when she becomes an engineer.

Professional Performance

Evidence from interviews suggest that non-engineering academicians seem to be facing setbacks in conducting sustainability based research, the overarching research agenda of the university. A5 commented that non-engineering academicians with expertise in marketing may find it possible to participate in the mainstream sustainability research groups to market the findings of a research. However, those from the language and communications unit, she said, found it challenging to become members of sustainability based research, whose members mostly consisted of engineering academicians conducting engineering based sustainability research. Said A5, *maybe the marketing people can go in but now language communication part... I don't know* (A5, lines 85-86).

While A5 found it a challenge, A8 said she had no desire to collaborate on research with engineering academicians as she preferred to work on research within her own area of expertise. She also commented that engineering academicians should take into account the non-technical aspects of their research and provide a non-biased observation of the research they conduct.

> *In a way it has but ... but I I have..I don't bother you know... I just do my own research and and I don't wish to even... you know collaborate my work with them even...yeah.. for sustainability because they are the ones who know about the technicalities of this so called scientific innovation, we don't know*
>
> (A8, lines 84-92)

EP3 commented that the practice of making academicians fit into a specific research focus could jeopardize their specialization. He was appalled that the university failed to recognize and respect the non-engineering academician's authority over his or her area of expertise, by forcing them to work on areas of research the university had an interest in.

> *they must have respect they don't have respect for traditions..we are authorities you know, I feel, they develop our authority our expertise ... with a track record the repetition over decades and this will last for over three decades or so, suddenly they want me to do social impact study or some kind of waste water measurement I'm not going to be known for that doing for whatever I've done last 30 years. I chose my own area of expertise of interest they don't have the right or authority force me to choose what they have in interest.*
>
> (EP3, lines 160-166)

A7 explained that engineering academicians must not just assume that the non-engineering academicians could fit into the engineering based sustainability research they conduct. Said A7.. *don't just assume that anyone of us can actually fit in there ... because what's the relevancy and we'll have to remember at the end of the day that we are being assessed* (A7, lines 74-76). A7 also mentioned that the teaching and research that academicians conducts must be linked. A7 noted that this teaching-research link was presently fuzzy. While the sustainability research direction of the university seemed clear, it was still ambiguous where sustainability was headed towards in respect to teaching and the undergraduate engineering curriculum, said A7 further.

> *maybe there is a, there is a direction for research ... i don't see how we can take that in to put in into our teaching ...there is two different thing there you know research and teaching of course there should be a link as well because whatever research we do is based on whatever we teach but for the sake of research yes.. but for .. to to take what we do what is there in the research part and to put in our teaching to teach the student is still a dotted line there's a line but dotted because it's not really on what sustainability is all about for us to really tell them i don't see it la so because i don't see. we don't even know where do we stand*
> (A7, lines 36-43)

A6 who initially stated that research that he undertook was not linked to sustainability, later said there may be some links to sustainable development. The hesitance projected by A6 suggests a larger issue at play, i.e. the lack of understanding of what sustainability entails.

> *I am working on this..what we call it, plant turn around...but I don't know how that relate to sustainability lah, okay okay maybe in terms of helping the company.. with this cost, the induction... yes yes yes could be lah, yes that's possible lah*
> (A6, lines 57-65)

A6 also commented that it was not only the non-engineering academicians who faced problems in engaging with sustainability based research groups in the university. There were engineering academicians who also faced similar predicaments. Said A6, *We don't fit, we don't fit in fact some of the engineers over the other side in civil, also they don't fit* (A6, lines 129-130). However, A6 said that the main problem that has resulted for non-engineering academicians as a result of the establishment of sustainability research groups was the limited opportunities they faced in becoming principal investigators in research undertaken by the sustainability research groups in the university. This was due to the fact that human or societal research issues which non-engineering academicians usually researched upon were not always the main issue investigated in the university's sustainability research groups. Noted A6, *how can I become a PI, that basic reason is the area is not ours, unless, we we definitely we have lah this human element, societal and all that but that's not the main thing, so just only become the research member* (A6, lines 139-142).

Interviews also suggest that engineering and non-engineering academicians were unclear of their roles in contributing to the university's sustainability agenda, which was viewed as a setback to their teaching responsibilities. A7 mentioned that such ambiguities led to the situation of the blind leading the blind, making any form of contribution impossible.

> *if you expect us to teach sus..sustainability ...but we are not sure of the role we play.. how we going to actually teach them you know. or else you'll be a blind man leading another blind man ... we don't have enough support to acquire more knowledge* (A7, lines 77-84)

A5 commented that engineering lecturers were not fully aware of the research non-engineering academicians undertook. A10 explained that he was not very familiar with the sustainability direction the undergraduate engineering programme was moving towards, suggesting that engineering academicians were equally vague on their roles in conducting sustainability based research.

> *I mean when you talk about sus, everyone likes to talk about sustainable, but what exactly sustainable ...Especially in the engineering perspective, I..mean that's the, that's the kind of question that actually before anyone says anything ha, hurm, everyone should know what exactly it means by that.*
>
> (A10, lines 19-24)

The interviews suggest that academicians from the department of Management and Humanities faced challenges in conducting research within the context of sustainability. A5 explained that academicians from this department were often not recognized for their areas of expertise, but were asked to try their best to assimilate with the engineering academicians' sustainability research groups. Noted A5, *They said that they do not recognize us right now, they they want us to assimilate some what we know into their field* (A5, lines 98-99). A7 on the other hand commented that academicians from this department were sought by engineering academicians at the tail end of the research. This resulted in them playing the role of followers instead of leaders of the research.

Engineering academicians however had very different views from that of the non-engineering academicians. A2 said that academicians from this department had the expertise in conducting surveys and investigation social dimensions of sustainable development research.

> *We are ... what you call that uh [the tail end..] tail end or in between when we come in you know again we play the role of followers instead of leaders because when they need us then we come in so.. that's not sustainable la ... it's not..it's not because you only use the resources when you feel you need to use and all so I .. think it's and it's difficult for us to inculcate culture that would contribute to sustainable development it will be don't recognize the role of others i think that was .. really challenging la to us*
>
> (A2, lines 164-171)

A1 indicated that it was wrong for non-engineering academicians to say that they were unable to fit in the sustainable research conducted by engineering academicians as they had the expertise in managing a research project.

> *It's not a right thing, that's not the right thing. because when I teach engineering, i only teach engineering... it has to be the management, running a plant but obviously you need the management skills ... I think the management lecturers, are the ones who are, the right person to talk about sustainability*
>
> (A1, lines 176-186)

It was fascinating to find that U3 was of the opinion that non-engineering academicians did not need to be involved in the assessment of undergraduate engineering students' final year project and engineering team projects. He commented that the involvement of non-engineering academicians in these assessments were irrelevant and unimportant. He said that it also projected that non-engineering academicians were becoming involved in these assessments for the sake of fulfilling their KPIs and not due to their interest in the projects, making them look irrelevant in the project.

The interviews also suggest that the inclusion of sustainable development within the undergraduate engineering curriculum could have an impact on the academicians KPIs. Interviews suggest that the current teaching and research KPI system practiced in the university may not be sustainable in its approach. A3 for instance said that the tri-semester system which was very packed for students and lecturers alike had an impact upon her KPI. A7 was also concerned that the KPIs and assessment of academicians had an impact upon teaching. A9 commented that the present KPIs were not favourable to non-engineering academicians.

> *..aa..actually, last week we did our workshop... none of the initiatives of KPI directly clearly mention bout our field here from social science and humanities, we did raise up, we did mention, we did ask then still, the person they said, till the now the management said you can tell the initiatives, you can tell the idea, but we can't change, so what for?*
>
> (A9, lines 133-139)

U3 agreed that the present KPIs which were a one size fits all initiative was problematic for the non-engineering lecturers. He said it was therefore important for them to be able to justify why they are unable to conform to these KPIs during the assessment process.

A11 cautioned that the corporate vs. academic culture was a challenging contradiction to negotiate. He added that the university should have first determined the corporate and/or academic culture it wished to inculcate in the university prior to embarking on its sustainability journey.

> *... to promote sustainability, on an individual level, in my professional life, ahm, basically the number one challenge is that we are part of a corporation, we're under the umbrella of a corporation, and there's a corporate culture here, which presents an implicit contradiction with educational culture..no one wants to talk about it*
>
> (A11, lines 368-381)

A11 also commented that the present academic culture in the university made it difficult for the academicians from the management and humanities department to contribute to the university's sustainability research agenda as they were seen to play a secondary and marginal role in the university's sustainable development journey. He said, *but we have a handmaiden role, we don't have the initial, we have a handmaiden role,...so you could say supportive role, it's not some leadership role, it's a marginal role in the sense*
(A11, lines 451-454). A7 explained that a sustainable development culture would be difficult to inculcate in the university when the roles of the academicians were not clearly defined by the institution.

> *No. No mention at departmental level what more unit level of being part of the sustainable culture. ... I'm... I'm really sure*

there have been no mention ... don't expect us to ... what you call that contribute, made requirement towards ... you know, because people are not clear of what they suppose to do

(A7, lines 230-235)

Academician role

Most of the academicians seemed aware that they had an important task to play in developing undergraduate engineering students' awareness and understanding of sustainable development. A7 noted that it was the responsibility of the non-engineering academicians to instil the thought and importance of sustainability through the modules they teach.

> *I think people like lecturers in other area of ...other than engineering have got the role to ... not just teach but also to I wouldn't say teach in a way where you just go to class and lecture them but instilling and the thoughts the importance of sustainability through whatever that we teach in our ... subjects and what you call that emphasizing on the importance of understanding what sustainable means*
>
> (A7, lines 77-81)

U3 explained that non-engineering academicians could help strengthen undergraduate engineering students' communication etiquette, which he saw as essential in bringing forth the university's sustainable development initiatives. He said, *so coming back to our earlier explanation, how about our non-engineering lecturers , so they come in to strengthen the communication part , the etiquettes you know to give them a different view it's not to tell them okay it's all about technical* (U3, lines 492-495).

U1, the Vice Chancellor of the university emphasised that teaching dedication and networking played an essential role in driving forth the university's sustainability agenda.

> *First, I hope but I don't know but we must do something different , not the normal teaching ... lecturers in the case of engineers maybe they have to be attached with the industry they must understand the industry , ... i think yet to see people going into sabbatical... I think lecturers must be more dedicated not one hour teaching that's it hurm, there must be this new style to make the teaching interesting aah ... I think there's a way they can contribute must sacrifice not just between 8 to 5*
>
> (U1, lines 43-57)

Engineering industry practitioners like IP1 was of the opinion that awareness and belief was of essence. He commented that academicians should be appropriately exposed to sustainability in order to understand what sustainable development was so they could communicate and impart this knowledge to their students appropriately.

> *I think number one is the awareness must come to the person first ... he must be aware of what is sustainability, so it's a very important thing the academicians themselves must be properly exposed must properly understand what is sustainability and why it is development and how we can contribute to the society the it's so much easier for them to share the knowledge with the students if not it becomes a very academic exercise*
> (IP1, lines 323-330)

EP8 on the other hand was of the opinion that academicians brought in their own set of knowledge and beliefs, and this should be reflected through the research they perform.

> *... to some extent they also, it also needs to reflect their own, their own you know research, competence, so….And again, you can be a believer but you need to have the right knowledge. And quite often that means that you … its somewhere or rather your researching it. So it's… you don't want people doing, if you don't know anything about it* (EP8, lines 161-178)

In terms of teaching responsibilities, A8 and A9 were of the opinion that teaching was of priority, while A11 preferred facilitation of the learning process. A2 on the other hand said he sees himself more as a researcher than a teacher in bringing forth the sustainable development agenda.

> *I think my role should be more should be coming up with research which ties up with this sustainability agenda...I think it's more tied up to the research. whatever research that you you you doing* (A2, lines 148-155)

A4 was of the opinion that academicians teaching the Professional Communication Skills module could advocate sustainability through teaching, by developing presentation tasks related to social issues pertaining to sustainable development.

I believe that the course will deal a lot based on oratory skills you know, there will be presentation. So the lecturers can play a role in a sense that can design an assignment or project to tackle the issues in sustainable development. ... So, I think it will generate the the interest you know? I mean, not not only for the students but the interest or the non-engineering lecturers can see that they are also important.

(A4, lines 136-146)

Although A10 is an engineering academician, he explained that he was not comfortable approaching or teaching sustainable development in the modules he teaches.

If limiting to my subjects, comfortable quite limited.it it say its limited means pretty much I would say not comfortable, because because there's nothing there for me to say or to demonstrate or to encourage them to as , if you're talking about covering of all that few things it's just about economy or about sustainable circuit design that's all, that's another issue[alright] so, depends on how you look at it lah honestly

(A10, lines 41-45)

U2 commented that academicians should consciously approach the teaching of sustainable development to concretize the university's sustainable development initiative in a more formal approach.

I cannot say whether the lecturers are doing these consciously or not, but I'm sure the lecturers today are very sensitive to sustainability development... Maybe we need to add more, on a more conscious mode, maybe it should be...how do you say, highlighted somewhere that it is important and be presented in a formal way

(U2, lines 98-104)

U2 was also of the opinion that non-engineering academicians should discuss sustainable development in their modules through the use of teaching approaches related to the concept, in addition to conducting group discussions, competitions, contests and debates related to sustainability.

Urm...again to communicate this to students, also maybe through class discussion, it can be done easily, in terms of providing reading materials and maybe also, coming up to competition, example education contest even debate whereby sustainability will be discussed. So, I believe that they can play a very important role in a, in community this message across.

(U2, lines 118-124)

S5 however thought it would be more effective for academicians to play a more active role in creating sustainable development awareness during lecture sessions. Said S5, *I think lecturers should play a role, because everyone will go to the lectures, not everyone will join events, so at least give us an idea what sustainability is and how we can contribute just by, apa, just by talking about it in their lectures* (S5, lines 160-163).

University management role

Industry practitioners and academicians were of the view that the university management had an important role to play in relation to the inclusion of sustainable development in the undergraduate engineering curriculum. IP1 commented that it was essential for universities to create awareness of sustainable development amongst its engineering students. Academicians were of the view that the university management had to play a greater role in advocating sustainability in the university. A8 for example observed that the university management was not doing enough to inculcate sustainability awareness in the university. Said A8, *No, no no.. I know Z* (interviewee stated the name of the HSE personnel in the university) *is looking into it within his limitations but I think more can be done... yeah I think more can be done* (A8, lines 115-116).

A2, on the other hand said that continuity of sustainability initiatives were jeopardized when personnel is charge of these initiatives are replaced with other staff members. He also commented that management had to be more forceful in implementing sustainability in the university.

> *Well we started it a little bit ...and it stopped there. and it's not, I don't know, it's not obvious enough, it's not highlighted through the emails, it just disappeared. it just disappeared, the management should be more.. how you say it, more forceful. in implementing this you know? before this, we talk about wastage of papers per department now it seems like it's dying down.*
>
> (A2, lines 216-222)

6.3 Discussion of key findings

The findings reveal several pertinent issues that the university has to look into to enable its transition towards the inclusion of sustainable development content within the undergraduate engineering curriculum. The key findings are discussed in the following paragraphs.

Sustainability competences for the engineering workplace

Final year undergraduate engineering students were of the opinion that it was necessary for them to be aware of what sustainable development entailed in their present state as undergraduate engineering students. They also viewed competences related to sustainable development as a pertinent element in preparation for responsibilities they would need to undertake when they become members of the engineering workforce. Competences students found to be most important in preparation for the engineering workplace were:

a. understanding how science and technology has changed nature and people's effect to the environment
b. appreciation that current actions can impact on the quality of life of future generations
c. ability to participate in groups consisting individuals from many fields or disciplines of study to jointly evaluate causes, put forward and work out problems, and provide solutions to problems
d. ability to apply engineering skills to solve real life sustainability problems facing society
e. being able to hold appropriate understanding of how the economy, society and environment affect each other

Competences perceived to be least important for workplace responsibilities were:

a. understanding how cultural and social values influence how resources are viewed
b. ability to apply social science and humanities concerns to solve real life sustainability problems facing society
c. managing and directing change at individual and social levels

d. applying business and management skills to solve real life sustainability problems facing society
e. being able to express personal responses to environmental and social issues

Astonishingly, the most and least important sustainable development competences in preparation for workplace responsibilities bear similarities to some of the sustainable development competences students perceived to be included in the present undergraduate engineering curriculum. The top three competences for workplace preparation were also the top three competences students perceived the undergraduate engineering curriculum to have already included. Interestingly also, the item perceived to be of least presence in the undergraduate engineering curriculum at present, was also the competence viewed to be the least important in preparation for responsibilities at the engineering workplace.

Interviews revealed a consensus of opinions amongst academicians, undergraduate engineering students and engineering industry practitioners on the benefits of being sustainability conscious at the workplace. There were, nevertheless, setbacks to be addressed, as it was found that the engineering industry professionals were concerned that Malaysian engineering graduates lacked understanding of sustainability competences. This has an adverse effect for engineering industry employers, as resources were wasted on retraining the graduates so they would be conscious of the need to be sustainable when dealing with sustainability related workplace tasks. These findings are indeed a cause for concern. While the Malaysian professional engineering body stipulates the need for the country's engineers to be sustainability competent, the actual situation seems to suggest otherwise. Sustainable development and sustainable engineering specific dialogue between Malaysian engineering industry stakeholders and Malaysian higher education stakeholders should therefore be carried out. Such engagement will promote better comprehension of the present gaps in the undergraduate engineering curriculum, and would address the concerns surrounding the nation's sustainability incompetent engineering graduates.

Besides this, a lack of understanding of sustainability competences was also found amongst academicians, as the interviews indicate that this group of stakeholders did not fully understand what these competences entailed. As a result of this lack of understanding, academicians were found to rarely relate sustainability and sustainable engineering issues to the modules they taught. These findings are similar to findings of studies conducted by Valazquez et al (2005), Martin et al (2006) and the WWF (2007). Literature discussed in Chapter 2 of this thesis clearly indicates the important role educators play in nurturing sustainability competent graduates, and the pedagogical problems faced by educators in developing sustainability consciousness amongst students. The lack of understanding of sustainability competences amongst the educators points to a serious need for the university to develop ESD pedagogical support mechanisms to assist educators in playing their roles more effectively. An initiative similar to the UNECE (2011) ESD competences is a possible pedagogical support mechanism that could be developed to address this concern.

Another concern is for University X to decide upon the sustainable development angle it wants to focus upon. As sustainable development was only recently introduced, it would augur well for the university to establish and work towards a special sustainability focus first, before venturing into broader angles of sustainable development. Making this decision would therefore be vital as it would have an impact upon adaptations that have to be carried out within the undergraduate engineering curriculum to enable students develop the sustainable development or sustainable engineering competences they would need in preparation for the workplace. The lack of a sustainability focus was a similar factor deterring the inclusion of sustainable development within universities, as seen in the study conducted by Valazquez et al (2005) and Scott et al (2012).

Impact of inclusion of sustainable development in the undergraduate engineering curriculum on the professional performance of the academicians

The interviews also indicate that the inclusion of sustainable development within the undergraduate engineering curriculum had an impact on the professional performance of the academicians. Given that academicians are uniquely positioned to be agents of change for the communication of the university's sustainability agenda to the student stakeholders, the issues faced by this group of stakeholders would therefore be necessary to explore.

Research performance was one of the issues highlighted during the interviews. Findings suggest that both engineering and non-engineering academicians were facing problems in conducting research related to sustainable development. Interestingly though, the non-engineering academicians were found to be facing relatively more difficulties in comparison to the engineering academicians, with a major setback being the inability to become principal investigators in sustainability focused research projects. Given this predicament, the non-engineering academicians revealed that they would rather work in silo, than having the engineering academicians assume that they could just fit into the sustainability research the engineering academicians led. The findings of the present study on preservation of expertise found in the present study, was also found to be a similar finding in Mulder and Jensen's (2006) study. The findings of their study show that academicians insistence of conserving their expertise as a major deterrence to the inclusion of sustainability within the engineering curriculum. The university could therefore consider sending its academic staff for ESD related professional development modules or training programmes to develop pedagogical and research competences related to teaching and researching sustainable development.

Findings also show that non-engineering academicians were not recognized for their expertise, but were instead asked to assimilate into the engineering based research conducted by the engineering academicians. This made the non-engineering academicians feel less appreciated and demotivated, as they were seen to be followers instead of leaders of the research. Findings of the present study also confirm findings of the study conducted by Brinkhurst et al (2012). Additionally, the non-engineering academicians' insistence of preserving their area of expertise was found to have an impact on their ability to teach. Given that research and teaching are entities that are closely linked, it is thus believed that these findings do not augur well for the inclusion of sustainability within the undergraduate engineering programme at University X.

While the sustainability research direction of the university is apparent, it was nevertheless found that there still were ambiguities in relation to where the university was moving towards in relation to sustainability related teaching. These findings are an indication for the university to move towards a strategic focus for sustainability. This suggestion is in line with recommendations suggested by a study conducted by Scott et al (2012), which emphasise the necessity for universities to sharpen the focus of understanding of ESD to create a smoother transition towards sustainable development in institutions of higher learning.

Interviews further suggest that the inclusion of sustainable development in the undergraduate engineering programme could have an unfavourable impact on the academicians' KPIs. Academicians were of the opinion that their teaching and research KPIs were unsustainable, while the one size fits all KPI system practiced by the university was not favourable to the non-engineering academicians.

Besides unsustainable KPIs, it was also found that the university was facing challenges in negotiating between its corporate and academic culture. It also appears that the present academic culture was less favourable to the non-engineering academicians, as this group of stakeholders felt they were playing a secondary or marginal role in the university's sustainable development endeavours. These findings are similar to the findings of the study conducted by Mulder and Jensen (2006), where it was highlighted that an ill-defined academic culture was found to be a threat to the integration of sustainable development in engineering education. Clearly defined academic and professional development guidelines for all academicians are thus seen as a possible solution to this problem. The university should also clearly delineate its corporate and academic culture and include sustainability as a university ethos so it is appropriately institutionalized within the university's curriculum and policies, in tandem with the whole institution approach to sustainable development.

Responsibilities of academicians and university management in carrying forth the sustainability agenda

Interviews revealed that most academicians acknowledged the importance of their role in developing undergraduate engineering students' awareness and understanding of sustainable development. University management members as well as practitioners of the engineering industry also agreed that academicians had an essential task to play in instilling such awareness in the students. Non-engineering academicians were seen to be particularly beneficial in strengthening students' communication skills. Industry practitioners however felt that all academicians should be provided with appropriate levels of exposure to sustainable development to enable them to communicate and impart knowledge of sustainability to the undergraduate engineering students appropriately. It was also found that it was necessary for academicians to use their existing knowledge and set of beliefs to impart knowledge on sustainability and at the same time reflect this through the research they performed.

Academicians however seemed to be of mixed perceptions in terms of their responsibilities towards teaching. Some saw themselves as facilitators of the learning process, with a need to focus on the teaching of sustainability. Others placed higher priority on research in comparison to teaching. Interviews also found academicians to be uncomfortable in approaching sustainable development within the modules they presently taught. Such reactions, according to Sterling (2004), are common, and are an indication that the academicians may not be ready for the integration of sustainable development content within the curriculum, through the built in approach. Given these interesting findings of the study, it is encouraging nevertheless to find some academicians looking at themselves as facilitators of the learning process, instead of instructors, as these findings suggest manifestations of transformative education.

Industry practitioners and academician stakeholder groups were in agreement that the management of the university needed to play a greater role in advocating sustainability consciousness in the university. Similar concerns were found in studies conducted by WWF (2007) and Valazquez et al (2005). In the present study, findings suggest that there is an immense need for rigorous implementation of sustainability policies in the university. These setbacks are seen to be factors preventing sustainable development initiatives in University X, and must therefore be addressed promptly if the university is serious about its inclusion of sustainable development within the institution.

Research Question 2b

This research question aimed at exploring stakeholders' perspectives on the inclusion of the 30 sustainable development competences as educational outcomes in the undergraduate engineering curriculum in the common engineering and non-engineering modules and university programmes. The findings are as discussed in the sections that follow.

6.4 Key findings and discussion on student stakeholders' survey on the importance of the inclusion of the 30 sustainable development competences in common engineering and non-engineering modules and university programmes

The student stakeholders' survey revealed fascinating findings on the inclusion of the 30 sustainable development competences in common engineering and non-engineering modules and university programmes. None of the common undergraduate Engineering, English Language and Communication and Business and Management modules presently prepares the engineering students to solve real life sustainability problems facing society. Undergraduate engineering students also do not seem to be provided their desired opportunity to be able to participate in transformative activities through cooperative, collaborative and multidisciplinary learning platforms. Interestingly, the top two most important competences for inclusion in common engineering modules, featured as the least important sustainable development competences in the English and Communication, Business and Management and Social Science and Humanities common modules. The possible reason for this competence to be featured as the least important competence for all the common non-engineering modules is probably due to the reason that it involved the application of engineering skills to solve sustainability problems facing the society. Students could therefore have questioned the relevance of using engineering skills in non-engineering modules, thereby evaluating it as the least important sustainable development competence for the common non-engineering modules. Surprisingly though, both competences were perceived as sustainable development competences of most importance in preparation for the engineering workplace, indicating a mismatch in engineering students perceived importance of these competences for workplace and academic preparation.

From an ESD perspective, students views of these competences not being essential competences to include in their English and Communication, Business and Management and Social Science and Humanities common modules suggests that the present undergraduate engineering curriculum does not seem to be nurturing students towards multidisciplinarity and transdisciplinarity, which are key features of a transformative sustainable engineering curriculum. This could be a possible reason for students viewing the inclusion of these competences less favourably within these common modules.

Another fascinating finding was the perception of undergraduate engineering students of the importance of competence 15 and 6. These findings are attributed to the lack of focus on the importance of multi and transdisciplinarity for sustainable engineering, within the university's present undergraduate curriculum. Common business and management modules are also found to be not preparing the undergraduate engineering students for situations that require them to solve real life sustainability problems facing the society through the application of business and management skills. The findings however suggest that students are being given the opportunity to apply these skills through non-academic platforms, i.e. through University Programmes.

6.5 Key findings and discussion on the relevance of the 30 sustainable development competences in the common engineering and non-engineering modules and university programmes by non-student stakeholder respondents

As a group, the results of the non-student stakeholders' survey suggest that the highest percentage of relevance for a competence was 88.24%. This indicates that 15 out of the total 17 respondents perceived that a particular sustainable development competence was relevant for inclusion in the common engineering and non-engineering modules and university programmes. Four competences were found to be within this category. These were competence 13, *Apply language and communication skills to solve real life sustainability problems facing society*, competence 18, *Able to express personal responses to environmental and social issues*, competence 28, *Respect and value cultural, social and economic and biodiversity* and competence 29, *Appreciation of the variety of approaches to sustainability issues*. Surprisingly, the sustainable development competence perceived to be the least relevant by the group was competence 15, *Apply social science and humanities concerns to solve real life sustainability problems facing society*. This competence received a relevance percentage of only 58.82%.

While literature on sustainable engineering advance the need for engineering graduates to be savvy of societal and human concerns relating to sustainable development and sustainable engineering, these findings interestingly, contradict literature. Academicians and industry practitioners seem to be the majority of respondents who viewed this competence less importantly, prompting concerns that these groups of stakeholders may not be fully aware of its significance for EESD. Academicians particularly need to be engaged in understanding this further, given their role in educating and nurturing sustainability competences amongst engineering students.

From individual respondent perspectives, it was found that seven out of the total 17 respondents perceived that all 30 sustainable development competences were 100% relevant for inclusion in the common engineering and non-engineering modules and university programmes. These seven respondents included two ESD experts, one ESD practitioner, one academician and three engineering industry practitioners. Three respondents perceived that the 30 sustainable development competences were not very relevant for inclusion in the common engineering and non-engineering modules and university programmes. These respondents included two academicians (one engineering and one social science and humanities academician) and two engineering industry practitioners who each perceived the competences to be 40%, 43.3%, 33.3% and 10% relevant.

A possible reason for the low rating of the relevance of the 30 sustainable development competences provided by the two academicians could be due to the fact that they perceived some of the competences to be beyond the scope of their expertise. This is apparent in the rating provide by A9, a social science and humanities academician, as she seems to have only perceived most of the sustainable development competences related to values, social aspects and society as relevant. IP6 who only perceived 10% of the sustainable development competences to be relevant rated the application of engineering skills, English language and communication skills and business and management skills as the necessary competences for inclusion in the common engineering and non-engineering modules and university programmes. His rating suggests that the engineering industry is presently facing a shortage of engineering graduates who are able to effectively perform these skills to handle real life sustainable engineering problems. These findings suggest that engineering education programmes in Malaysia need to pay additional emphasis on these skills in the development of the undergraduate engineering curriculum, to develop multi and transdisciplinary competent engineering graduates, in tandem with the goals of EESD.

Research Question 2c

This research question explored stakeholders' perspectives on modifications that need to be made to the 30 sustainable development competences to enable its inclusion as sustainable development competences and educational outcomes in the undergraduate engineering curriculum. Findings are discussed in the paragraphs that follow.

6.6 Key findings and discussion on suggested improvements for the 30 sustainable development competences

The expert review conducted by the UNESCO Chair in Social Learning and Sustainable Development suggest that the 30 competences that were developed were appropriate and relevant for inclusion as undergraduate engineering program outcomes and undergraduate module learning outcomes. The review also found that it would be more appropriate if the term 'competences' were used to describe the 30 competences developed. The expert review also indicated that 30 competences may be too many, which at times could lead to it being viewed as too focused, and may not necessarily be as comprehensive as it should. Concerns highlighted by the UNESCO Chair were adapted by labelling the 30 learning outcomes as competences.

ESD experts were of similar views on the use of the term 'competences' so it would be more aligned with recent international dialogues in ESD and EESD. They also suggested for distinctions to be made between competences that were engineering specific, and competences which were generic. Besides communication and language, the context, culture, history and geography were also seen to be important factors to ponder upon in developing the competences. The context in which the learning outcomes are developed was also a point highlighted by the experts.

Concerns highlighted by the ESD experts were addressed through the Principal Component Analysis method. The dimensions derived from the analysis were labelled accordingly. The element of context, culture and geography are already embedded in the 30 competences developed, and were thus not addressed. History on the other hand is not embedded in the 30 competences presently, and is a competence which will be considered for inclusion in future research.

ESD practitioners on the other hand suggested that the 30 competences could be used as an overarching framework, with specific competences extracted to be used as learning outcomes for different modules offered in the undergraduate engineering programme. They also cautioned against the use of verbs such as 'understand', 'appreciate' and 'apply' as it could be difficult to assess from the context of sustainable development. The concern on the use of the verbs ‘understand’ and ‘apply’ was not adapted, as these verbs are commonly used as action verbs to describe learning outcomes in an outcome based engineering education curriculum in tandem with Bloom’s taxonomy. The verb ‘appreciate’ is not a common Bloom’s taxonomy action verb and is difficult to measure as a learning outcome. This suggestion will thus be kept in view for future work.

Academicians also suggested the need to include a list of examples of sustainable development topics that could be included as topics or issues in the undergraduate modules. As the focus of the study is not the development of sustainable development issues or topics that can be included in the common undergraduate engineering modules, this suggestion was also not addressed, to allow room for future work.

Industry practitioners provided suggestions to expand the description of some of the 30 competences developed so it would be more aligned to the needs of the engineering industry. Suggestions include the need to expand the term ‘holistic’ to include technical, environmental, human, societal, and cultural aspects. The term ‘community based problems’ was suggested as a replacement for the term ‘complex problems’, while the phrase ‘play the role of responsible citizens at the local and global level’ was suggested to be amended to ‘contribution to the nation’. Religion was also suggested to be added to the item ‘respect and value cultural, social, economic and biodiversity’. The aspect of engineering development, sustainable engineering culture norms and codes of practices, and future impact was also proposed for inclusion. Suggestions were also provided by industry practitioners to expand upon the specific communication, business and management skills needed within the context of sustainable engineering, so that it is aligned with the needs of the engineering industry. In relation to the business skills needed, industry practitioners suggested expanding the competence by including cost cutting measures, loss of production time, minimizing energy wastage, operating cost impact and energy management are elements related to business and management skills and negotiation skills in selection of vendors and raw material suppliers that practice sustainable measures in their business. Communication skills were suggested to be expanded through the inclusion of the ability to express ideas with a variety of people involved in the engineering and business context i.e. the customers, the sales personnel, the marketing personnel, the process and product development engineers, the production personnel, the finance personnel and the administration personnel, ability to express ideas and opinions to colleagues of the same level and members from the middle and upper management, practicing two way communication, ability to talk and explain intelligently and sensibly and the ability to discuss and promote ideas. Industry practitioners' suggestions on expanding the scope of the competences are useful as it gives a clear understanding on the sustainable engineering competences required of engineering graduates. The expansions suggested however will not be incorporated in the grouping of the competences. Instead, it can function as appended information, to be used as an additional source, along with the grouping of competences.

6.7 Guidelines to incorporate sustainable development competences within the undergraduate engineering programme outcomes and common module learning outcomes

In Section 4.3 of this thesis, 30 competences that relate to the sustainability literacies engineering students need to be exposed to, to enable them to practice, appreciate and understand sustainable development and sustainable engineering upon graduation, was discussed. These 30 competences were validated by a UNESCO Chair in Social Learning and Sustainable Development and deemed to be appropriately encapsulating sustainable development competences. The competences, as listed below, were further quantitatively tested through Principal Component Analysis (PCA).

1. Understand people's relationship to nature
2. Hold appropriate understanding of how the economy, society and environment affect each other
3. Hold personal understanding of the environment which is derived from direct experience
4. Local to global understanding of how people continuously impact on the environment

5. Understand how science and technology has changed nature and people's effect to the environment
6. Understand how cultural and social values influence how resources are viewed
7. Analyse a sustainability issue creatively, critically and systemically using scientific, social science and humanities approaches
8. Able to consider present and future directions of society and environment, and personal role and contribution to the future
9. Think of a holistic approach to solving an engineering problem
10. Think of a holistic approach to solving real life complex problems
11. Able to participate in groups consisting individuals from many fields or disciplines of study to jointly evaluate causes, put forward and work out problems, and provide solutions to problems
12. Apply engineering skills to solve real life sustainability problems facing society
13. Apply language and communication skills to solve real life sustainability problems facing society
14. Apply business and management skills to solve real life sustainability problems facing society
15. Apply social science and humanities concerns to solve real life sustainability problems facing society
16. Able to critically reflect on own assumptions and assumptions of others
17. Able to critically reflect on issues on a personal and professional level
18. Able to manage and direct change at individual and social levels
19. Able to express personal responses to environmental and social issues
20. Ability to demonstrate and articulate sustainability related values such as care, respect, charity, social and economic justice, commitment, cooperation, compassion, self-determination, self-reliance, self-restraint, empathy, emotional intelligence, ethics and assertiveness
21. Play the role of responsible citizens at the local and global level for a sustainable future
22. Develop appreciation of the importance of environmental, social, political and economic contexts of engineering processes for sustainability

23. Consider implications of engineering processes in relation to the environment
24. Consider implications of engineering processes in relation to the society
25. Consider environmental issues in relation to the society
26. Appreciation of all living entities
27. Appreciation that current actions can impact on the quality of life of future generations
28. Respect and value cultural, social and economic and biodiversity
29. Appreciation of the variety of approaches to sustainability issues
30. Appreciation for the need for lifelong learning in relation to sustainability issues and change

Following the results of the PCA, the competences were grouped to form the guidelines presented in Table 6.1. Echoing interview findings which support the need for guidelines to incorporate sustainable development within teaching and learning practices, the guidelines proposed in Table 6.1 thus forms an important outcome of this study. The guidelines illustrate the manner in which sustainable development can be incorporated holistically within undergraduate engineering programme outcomes and learning outcomes of Engineering, English Language and Communication, Business and Management and Social Science and Humanities modules.

Table 6.1: Guidelines to incorporate sustainable development competences holistically within undergraduate engineering programme outcomes and common module learning outcomes

Undergraduate Engineering Programme Outcomes	
Category guideline	**Competences**
1 Competences for comprehension, expression and demonstration of sustainable development consciousness	1, 2, 4,5, 19, 20 and 21
2 Competences for community based problem resolution	13, 14 and 15
3 Competences for holistic problem solving	9 and 10
Common Undergraduate Engineering Modules	
Category guideline	**Competences**
1 Competences for appreciation of the need for sustainability consciousness within engineering practices affecting society	22, 24, 25, 26, 27 and 29

2 Competences for the observation of sustainable development at individual and social levels	6, 13, 14, 15 and 18
3 Competences for comprehension, expression and demonstration of sustainable development consciousness	1,2,3,4,5 and 7
4 Competences for holistic approach to problem resolution	9 and 10
Common Undergraduate English Language & Communication Modules	
Category guideline	**Competences**
1 Competences for the comprehension of sustainable development	1,2,3,4,5,7,8,9,10 and 12
2 Competences for the expression and demonstration of sustainable development consciousness	20, 21,22, 25,26,27,28,29 and 30
3 Competences for implementation of sustainable development conventions within the community at individual, societal and professional levels	13, 17 and 18
Common Undergraduate Business and Management Modules	
Category guideline	**Competences**
1 Competences for the expression and demonstration of sustainable development consciousness	20,21,22,26,27,28,29 and 30
2 Competences for the comprehension of sustainable development	1,2,3,4 and 5
Common Undergraduate Social Science & Humanities Modules	
Category guideline	**Competences**
1 Competences for the comprehension of sustainable development	1,2,3,4,5,6,7,and 8
2 Competences for the expression and demonstration of sustainable development consciousness	26,27,28, 29 and 30
University Programmes	
Category guideline	**Competences**
1 Competences for the expression and demonstration of sustainable development consciousness at individual, professional and societal levels	18,22,23, 25,26,27,28,29 and 30
2 Competences for local and global comprehension of sustainable development using empirical and non-empirical measures	1,2,3,4,5,6,7 and 8
3 Competences for holistic problem resolution	9,19,11,12 and 13

The guidelines presented in Table 6.1 can be used by the university for two core academic purposes, namely teaching and assessment. At the programme outcome level for example, universities wanting to produce sustainability literate future engineers through their undergraduate engineering programmes can infuse three key competence areas within the programme outcomes. The three key competence areas are (a) competences for comprehension, expression and demonstration of sustainable development consciousness, (b) competences for community based problem resolution, and (c) competences for holistic problem solving as a possible undergraduate programme outcome.

Similarly, if academicians want to bolt-on or build-in module learning outcomes related to sustainable development knowledge, skills or attitudes in Engineering, English Language and Communication, Business and Management and Social Science and Humanities modules, the guidelines provide the key competence areas academicians should focus on to enable them to include these competences in the modules. For instance, English Language and Communication academicians who want to develop sustainability literate learners, or assess the extent to which their learners demonstrate sustainability literacy through these modules, could incorporate three key competence areas, namely, (a) competences for the comprehension of sustainable development, (b) competences for the expression and demonstration of sustainable development consciousness, and (c) competences for implementation of sustainable development conventions within the community at individual, societal and professional levels as learning outcomes or assessment measures within their modules.

In addition, the guidelines can also be used as a checklist by academicians who wish to evaluate the extent to which their modules include sustainability outcomes, prior to any bolt-on or build-in exercise. The guidelines can also be used as an instrument to assess the undergraduate engineering learner's level of sustainable development competence or the learner's self-perceived notions of their level of sustainable development competence. It can also function as a needs analysis or quality assessment tool for undergraduate engineering programme managers to determine sustainable development outcome gaps within the existing undergraduate engineering curriculum.

Research Question 2d

This research question sought to explore stakeholders' views on the manner in which sustainable development and ESD competences should be approached within the undergraduate engineering curriculum. Findings are discussed in the sections that follow.

6.8 Key survey findings on the manner in which sustainable development and ESD competences should be incorporated within the curriculum

The student stakeholders' survey revealed interesting findings on the manner in which sustainable development and ESD competences should be incorporated within the curriculum. It was also found that final year undergraduate engineering students were not in agreement of the teaching sustainable development in the undergraduate engineering programme as a separate engineering course on its own. It was also found that sustainable development should not be taught as a separate non-engineering course on its own. Respondents also disagreed that sustainable development input should be provided through engineering modules alone. Once again, there was disagreement for sustainable development input to be provided through non-engineering modules alone. It was found that respondents were in agreement that sustainable development input should be provided through all engineering and non-engineering modules, irrespective of if the module was a common module or otherwise. It also appears that all academicians, regardless of their expertise, should teach sustainability related content within the undergraduate engineering programme curriculum.

The open-ended responses of the student stakeholder survey sought final year undergraduate engineering students' views on pedagogical issues that they thought should be addressed in the undergraduate engineering programme. A total of 12 categories were found via NVivo analysis. Eight of these categories were from the responses obtained for the Engineering modules, while the remaining four were for the English Language and Communication, Business and Management and Social Science & Humanities modules. These responses are illustrated in Table 6.2.

Table 6.2: Open-ended responses on issues that should be considered for the incorporation of sustainable development and ESD within the undergraduate engineering curriculum

Engineering modules		English Language & Communication/ Management/Social Science & Humanities modules	
Categories	**Number of references coded**	**Categories**	**Number of references coded**
Practical vs. Theoretical	19	Communication and sustainable development	12
Real sustainable development issues and situations	19		
Sustainable development learning activities and assessment	13	Approach to teaching sustainable development for non-engineering modules	50
The need for heightened exposure and awareness to sustainable development post-graduation	6		
Teaching and learning of sustainable development via knowledge of current technological trends	14	Bringing real life sustainable development issues and situations into non-engineering modules	13
Sustainable development awareness through exposure within the engineering industry	11		
Sustainable development content within current learning modules	13	Relating engineering aspects with human and societal aspects	19
Approach to teaching sustainable development	30		

The paragraphs that follow summarize the Engineering and Non-Engineering Module responses of students in accordance to the open-ended categories.

Practical vs. Theoretical

The findings suggest that the undergraduate engineering curriculum is too theoretically oriented and does not place enough emphasis on practical, hands-on learning experiences.

Real sustainable development issues and situations

The findings suggest the need for teaching and learning practices to be modelled after real world sustainable development and sustainable engineering issues, from local and global perspectives. The application, effects and impact of sustainable engineering to the environment are also seen to be lacking within the present curriculum.

Sustainable development learning activities and assessment

The responses grouped under this category suggest that students want to work on activities and assessments related to real world sustainable development and sustainable engineering issues, which was lacking in the present curriculum.

The need for heightened exposure and awareness to sustainable development post-graduation

Student responses show that lecturers do not relate learning to students' future experiences in the field. Responses were grouped under this category.

Teaching and learning of sustainable development via knowledge of current technological trends

Student responses indicate that lecturers are not equipped with the necessary knowledge on current technological advancements in the field of sustainable engineering. Students also want to be exposed to the pros, cons and impact of the use of sustainable technology to the society and the environment. These were reflected through the responses.

Sustainable development awareness through exposure within the engineering industry

Responses show that students want to be exposed to sustainable engineering efforts taking place within the engineering industry. The responses indicate students are also eager for the university to include industry driven activities within the curriculum.

Sustainable development content within current learning modules

Findings show that common engineering module do not develop sustainability learning experiences for students. Lecturers were also found to be unable to relate sustainability to the technical, environmental and societal issues discussed in the modules they taught.

Approach to teaching sustainable development

Responses indicate that students want more transformative teaching approaches practiced by lecturers. These include discussions, practical and hands-on learning opportunities, multidisciplinary problem solving activities, case studies, field trips and project based learning.

Responses of the categories under the non-engineering modules open-ended category are as presented below.

Communication and sustainable development

Responses show that students are eager to learn methods of conveying environmental issues in a proper an effective manner to raise greater awareness of sustainability. Students also want communication modules to address the manner in which communication skills can be used to can alleviate appropriate mitigation approaches to sustainability problems facing the society.

Approach to teaching sustainable development for non-engineering modules

Responses indicate that students found non-engineering common modules to not relate sustainability within its contents. Similar to suggestions provided for the common engineering modules, responses also indicate that students want more transformative teaching approaches practiced by lecturers of the common non-engineering modules. These include field trips, having a practical and hands-on component within the modules that enable students to interact with the community and public on sustainability issues, involving the industry to better understand their views of the soft dimensions of sustainability, analytical thinking, and the need to include case studies that relate sustainability with non-engineering issues.

Bringing real life sustainable development issues and situations into non-engineering modules

Similar to findings of the common engineering modules, these findings also suggest the need for teaching and learning practices to be modelled after real world sustainable development and sustainable engineering issues.

Relating engineering aspects with human and societal aspects

Responses indicate that the present undergraduate engineering curriculum is not tailored to help students view the social implications of engineering and does not advocate awareness on their impact and role for sustainability.

The section that follows highlights the findings of the interviews.

6.9 Key findings of interview on the manner in which sustainable development and ESD competences should be approached within the undergraduate engineering curriculum

Higher education stakeholders, ESD experts and ESD practitioners' views were sought to explore their views on the manner in which sustainable development and education for sustainable development competences should be approached within the undergraduate engineering curriculum. These issues are discussed as follows.

Collaborative learning through sharing of knowledge and expertise by engineering & non-engineering lecturers

Academician A6 was of the opinion that collaborative teaching of sustainable development was a good move. Echoing similar sentiments was A10, who said that he does not see any problems with engineering and non-engineering academicians inviting each other to their module lectures to share their knowledge and expertise on sustainable development. However, he cautioned the need for the academicians to ensure they synchronize on the area or topic discussed.

> *No... I don't see a problem in that I guess you would have to see, they would have to talk about the same kind of area, or the same kind of topic, maybe give in a practise. Say for example, mine is purely electronic, alright where you talk about computers so how does that, sometimes you have to figure what exactly, say non engineering person, what is he gonna come and talk about computers*
>
> (A10, lines 170-174)

Final year undergraduate engineering students also welcomed this approach to learning about sustainable development. S2 for instance seconded this idea and provided examples of how she thought it could be accomplished.

> *…So, maybe can help us as a part as a lecture and maybe for your class ... you can invite an engineer lecturer to give technical us some kind of technical writing skills…Maybe they can ... call upon the business lecturer whoever...business department they can lecture and how can sustain the cost and gain the profit and so on.*
>
> (S2, lines 318-330)

A5 commented that the current practice of non-engineering academicians evaluating the technical presentation content of the Professional Communication Skills module was problematic. She added that it could also raise inappropriate assessment issues. A5 stated that engineering and non-engineering academicians should work together in the process of evaluation, where the non-engineering academicians evaluated presentation aspects, while the engineering academicians evaluated the content of the technical presentations.

> *… I think it's a good idea, but only for the content part the skills, some engineering lecturers do talk reality because they have a lot of presentations especially those who involved in vivas*
>
> (A5, lines 527-530)

A10 was also in agreement of this collaborative effort as long as the presentations were not too lengthy. He said, *Can, I guess it's not a problem, as long it's not too long* (line 199). S3 was of the opinion that collaborative teaching of sustainable development would not be effective for all modules in the undergraduate engineering programme. She suggested that collaborative teaching would be possible for engineering modules and communication modules. *…so I feel it should just confine within engineering, maybe mention,* *maybe mention case studies any courses like corporate communication, PCS, something* (S3, lines 394-509).

Interviews also indicate that engineering academicians were open to working on multidisciplinary research with non-engineering academicians. U3 also commented that it was possible to include a non-technical assessment component in the Engineering Team Research Project to encourage collaboration amongst the engineering and non-engineering academicians. Interestingly though, A6 contradicted these opinions as he revealed that opportunities for non-engineering academicians to be co-supervisors of Engineering Team Research Project and Final Year Undergraduate Engineering Projects were not easily available. He explained his experience of having to approach an engineering academician to offer his expertise, as if he were a beggar. He explained, *sorry lah, they* (engineering academicians) *will never never la kan kejar* (chase after us)*, we have to go them, I will go to Dr X what what we have to be like beggar lah , so have to do lah kan* (A6, lines 415-417).

Communities of Practice as a means of developing better understanding of sustainable development

It was found that readiness was an issue for non-engineering academicians if they were to be a part of the community of practice for undergraduate research. A5 for example stated that the problem with non-engineering academicians being supervisors for final year undergraduate engineering projects was that they need to have read up on the issue before being able to take up the supervision of research. She also said that non-engineering academicians need to become students as they need to learn new thing. A5 also explained that she was not comfortable supervising sustainable development based research projects as she is unable to position herself within the context of this form of research. *I don't think I'll be supervising [so how do you see yourself in this situation] aamm.. that's the thing we don't see ourselves as in the situation* (A5, lines 454-455), she said.

While A5 had problems associating herself with sustainable development based research, A9 on the other hand mentioned that engineering academicians were unaware of how they could tap into the expertise of non-engineering academicians to conduct research. A8 who has been an assessor of many final year projects, explained that final year undergraduate engineering projects pay less emphasis on human aspects of the research and are too engineering inclined. This suggests that such research projects would benefit from the community of practice initiative so as to enable non-engineering academicians to provide their expertise on human elements associated with the research to make it more sustainable and marketable.

Interestingly however, A7 said that she has been involved in final year undergraduate engineering project supervision and not the engineering team project research. She also explained that due to the fact that her language and communication colleagues merely got involved at the final stages of these projects (as co-supervisors for the presentation materials or to proof read language use in the presentation materials) and not from the time it begins, they are therefore not involved in the groundwork and do not really know what the project they have co-supervised actually entails.

It also appears that engineering academicians were very interested to work together with the non-engineering academicians to teach and develop modules related to sustainable development. A4 explained that he has no problem sharing the teaching responsibilities of his modules with his non-engineering counterparts. Similarly, A10 also expressed that he does not see any problems with non-engineering academicians inviting each other to their modules to teach sustainable development related issues. Interestingly, A1 commented that non-engineering academicians should be the ones introducing sustainability related content to the undergraduate engineering students, and not the engineering academicians. He also explained that both groups of academicians should work together to develop sustainability related modules, where the major portion of the module would be handled by the non-engineering academicians, with examples from the various engineering disciplines in the undergraduate engineering programmes offered in the university.

Interesting issues were revealed on the limitations of the community of practice approach. A10 for instance expressed the need for synergy between engineering and non-engineering academicians if this approach was to be implemented in light of sustainability teaching and research at the university. For U2, communities of practice may be difficult to sustain as students and academicians could have their own agendas, interests and aspirations. He also emphasised the need to make the initiative relevant so students would want to learn it without having their CGPAs in mind.

> *Ya, it's difficult because people probably have their own agenda, their own interest, their own aspiration. Students for example more concern is their studies. Urm..so they need to see to relate to this sustainability programme. What benefit is it there.* (U2, lines 263-267)

U3 however agreed that the community of practice approach was beneficial. However, he commented on the importance of establishing clear common goals. He further stressed that the absence of a clear and common goals could victimize the students, and cause academicians to impose their own views and values on sustainability onto others. He said, *You know if they are clear about their goals, their aims and goal, if they're not clear then it will be like people say blind leading the blind* (U3, lines 708-711).

Final year undergraduate engineering student, S4 was concerned about his study load if this approach were to be put into practice at the university. He said having the community of practice outside formal academic hours could be a challenge given the tight tri-semester schedule students had to endure. S3 had similar thoughts as U3. She stated that communities of practice were interest dependant. She said that the academicians should first take into account the interest of the students as students would just assume this initiative as just another task that needed completion, instead of taking it is a learnable experience. She explained, *I think first thing first is to gauge student's interest in sustainability, I think that's the most important because, if the student himself is not interested, he will not take it as a learnable experience, he would take it as another task to be done* (S3, lines 463-465).

It appears that the final year undergraduate engineering research project modules and the engineering team project component are suitable platforms for the community of practice initiative. U3 commented that the engineering team project was a good module to enhance, so as to provide the non-engineering academicians with the opportunity to be co-supervisors. S4 on the other hand explained that having both engineering and non-engineering academicians as supervisors for the research projects would be beneficial as students could obtain multiple input to make decisions concerning their research. He nevertheless mentioned that the involvement of language and communication academicians in the supervision process may not be beneficial.

S2 mentioned that civil, chemical and petroleum engineering students presently did not gain much from participating in the engineering team project as the research was more focused the use of knowledge and skills related to mechanical, electrical and electronics engineering suggesting that the proposed community of practice approach should take into account the development of research projects that involve students from all engineering programmes in the undergraduate programme. S5 on the other hand explained that the final year projects and engineering team projects were not synchronized with the expectations of the engineering industry. She said that these projects were presently very focused on the technical aspects, while in reality, the industry places importance on both technical and societal elements.

> *Yes yes. I think yes it's a good idea, when I go to internship, I can see that those things are taken into the consideration, but when we are doing our ETP or FYP we are only considering technical parts …maybe if we can incorporate into our ETP we can get more experience, we can think in a broader perspective.* (S5, lines 114-120)

Interviews revealed several benefits of the community of practice initiative. U2 explained that the initiative would be an advantage, as it would foster collaboration between engineering and non-engineering academicians. He said that most projects at present were only engineering based and should thus go beyond these parameters, but using a structured approach. S2 stated that being a part of the community of practice initiative with non-engineering academicians would benefit students in being able to develop their business strategy and thinking. S5 mentioned that she would want to be a part of the community of practice initiative as it would raise awareness on sustainable development.

> *I would say that I would want to be a part of that … maybe if we have that kind of group, we can share our ideas and opinions and maybe we can raise more awareness for other people.* (S5, lines 129-133)

Similarly, S1 commented that if engineering and non-engineering academicians were part of this initiative with the undergraduate engineering students, it would help students develop projects with the society in mind, and not only focus on engineering perspectives, as it was presently done.

> *I think that grouping will be a very good idea, for example when we take a ETP, when we do a ETP, we only take a look in the engineering aspect. In fact the project that we do, don't even look in relation to our thing our developed with the society itself.* (S1, lines 168-170)

Non-technical modules as a platform for sustainable development competences development

It was found that respondents were generally agreeable to introducing sustainable development content through non-technical modules offered by the department of management and humanities. A5 for instance claimed that these modules shaped values and etiquette. A2 was of the opinion that non-technical modules were a suitable avenue to discuss sustainable development aspects such as public perception and the impact of unsustainable development to the environment.

> *I would love to see more concrete work on the collaboration between the engineering and M&H where M&H I see the public perception where they go into the public... perception and the social aspects or of the people the.. of the public into the environment side*
>
> (A2, lines 163-166)

A3 commented that management issues related to sustainable development should be handled by the management academicians of the department of management and humanities.U4 however stated that a specific management and humanities based sustainable development module was not possible. He instead said that all modules offered by the department of management and humanities should include sustainable development content where possible. He said, *Sustainable, sustainability in this department is more on cannot have cannot have a specific module on its own, but what we can do we must embed in all the courses where possible* (U4, lines 41-43).

S1 however was concerned about making sustainable development content compulsory in all non-technical modules. This was because students viewed these modules less importantly than they did the engineering modules.

> *… it's a problem here, when we see the subject is not engineering related we put it aside and say, okay this subject is least important…it can also be a challenge for the non-engineering lecturer to promote and give awareness to the student that this subject is important to them to know, not just a university requirement, not the least important and something like that* (S1, lines 313-318)

IP1 suggested that the Professional Communication module offered by the department should incorporate the lessons on sensible reporting of information and articulation of thoughts in a manner which can be easily understood as these were communication competences the engineering industry sought from engineering graduates.

A3 commented that sustainable development content should be made a general university module which is open to all engineering disciplines. She further explained that making the module multidisciplinary in nature would be more effective.

> *If you make it multidisciplinary, i think besides we need... mechanical engineering itself we need a meeting itself to have a certain output because civil, chemical, EE they have their own output and sit together and discuss the whole curriculum, oww that one I don't how much time it will take, but it will be good if it is multidisciplinary because sustainable development is not only for mechanical engineers*
>
> (A3, lines 84-88)

EP7 explained that while it was essential for engineering students to be provided with multiple views on sustainable development although it may not necessarily be at the level of knowledge they would need to apply in their line of work.

> *Yeah, certainly it is , yeah otherwise I wouldn't be doing this work I think it's I mean it's true that it can be challenging for*

some students because it would not be the kind of knowledge that you would have that would need application in your line

(EP7, lines 73-75)

Interdisciplinarity, multidisciplinarity and transdisciplinarity through ESD

Interviews suggest that inter, multi and transdisciplinarity are not approaches commonly used in the undergraduate engineering programme. A1 for instance commented that he does not include non-technical aspects of sustainable development in the modules he teaches. A2 also stated that he does not do so, as the modules were not designed to include social or human aspects of sustainability. He said, *…because the syllabus not designed in terms of humanities aspects you know more engineering that's why the humanities need to be highlighted somewhere on the sustainability* (A2, lines 47-472).

Similarly, A10 also explained that he does not discuss other engineering fields as well as language, communication, business and social science issues in the modules he teaches, as the electric and electronics engineering modules were *very very focused on the EE kind of thing* (line 137), indicating that his module was very discipline centric. Interestingly, A4 said that he mentions other engineering fields as well as language, communication, business and social science issues in his Engineers in Society module. A3 on the other hand said that she did not make references of interdisciplinary nature in the modules she taught. She however said that she attempts to expose students to issues within the engineering industry via adjunct lecture sessions conducted by invited members from the engineering industry. Nevertheless, these adjunct lecture sessions only made up one or two hours of the 14 week semester.

U2 thought that a multidisciplinary approach was essential for teaching. He suggested that multidisciplinarity could be approached in undergraduate engineering modules by including the non-engineering academicians in the teaching of undergraduate engineering modules, so that this group of academicians could highlight the impact of sustainability from societal perspectives. Similarly, the non-engineering academicians could learn about engineering aspects of sustainability from the engineering academicians.

> *…because what the engineering lecturers do not see will be in terms of social impact, which the, maybe the social scientist can share with the engineering people. Then engineering people can also share with non-engineering lecturers on technology which is actually is non-destructive.*
>
> (U2, lines 178-184)

U3 commented that a multidisciplinary approach to sustainable development was necessary as the university's graduate student model was designed in such a manner. However, he cautioned that multidisciplinarity could make academicians defensive of their own areas.

> *We have to because we have our graduate model, it cannot be achieved within one discipline, so it has to be cutting the cross , multidisciplinary, whatever you wanna call it , you see the moment we came up with a model it cannot be done within a faculty , within a department within the programme but that's what people believe , they become like I said very defensive of their programme*
>
> (U3, lines 747-751)

Essential knowledge and skills to teach sustainable development

The desired ESD educator qualities are the ability to learn and unlearn (A4, U1), versatility (U3), dedication, having an understanding of the engineering industry, not merely academically oriented (U1), learning to see out of one's discipline, seeing beyond critical thinking and solution synthesis (U2), thinking out of the box, not having prerequisite notions about sustainable development, well read on sustainable development (IP4, EP3), being aware (IP1), having common sense, ability to connect research to teaching (EP1, EP4), ability to move out from one's comfort zone, ability to interact with people from different disciplines (EP7), being a believer with the right knowledge, self-awareness and awareness of others (EP8, EP4), ability to keep students engaged in sustainable development (EP5), enthusiasm, expertise and style (S4).

Engineering or non-engineering academicians for the teaching of sustainable development

There were mixed reactions on the best group of academicians to teach sustainable development to the undergraduate engineering students. The general consensus however seemed to be in favour of both engineering and non-engineering academicians teaching the sustainable development together. EP 1 explained that the best approach to teaching sustainable development was to have an engineering and non-engineering academician involved in the delivery of the module. This was due to the fact that it provided students with multiple perspectives of the sustainability issue discussed, given the different views provided by the engineering and non-engineering academicians of the issue.

> *...many of the courses in universities are now co – teaching , they bring more and more people from other courses I think that's helpful…I like students to be exposed to multiple perspectives that also mean non engineering people can play a big role in that . But they do should have some sustainability consciousness*
>
> (EP1, lines 272-277)

Some final year undergraduate engineering students like S5 and S1 were also in favour of engineering and non-engineering academicians coming together to teach sustainable development in the undergraduate engineering programme. S5 said that having engineering and non-engineering academicians discuss sustainability would enable engineering students to understand sustainability from technical and societal perspectives. *I think they should co-teach, because engineering lecturers can give a different perspective, technical perspective and non-engineering can give a society perspective* (S5, lines 256-258), said S5.

S1 had similar views. He also commented that the combination of the expertise of the engineering and non-engineering academicians would benefit students in understanding sustainability more effectively,… *so when these two lecturers are combined together, then we students we can get benefit from each lecturer, we can get the knowledge, from the engineering and we can get the teaching, the fun part from the non-engineering lecturers* (S1, lines 345-357). S4 however was of the view that engineering academicians would have the upper hand over non-engineering academicians the engineering academicians would be more convincing.

A3 stated that management issues related to sustainability should be taught by non-engineering academicians. Similarly, A1 was also agreeable to the non-engineering academicians teaching sustainable development. It was fascinating to find that A1 said that it should be the non-engineering academicians who ought to handle the major portion of the teaching responsibility. Interestingly, U3 said that the teaching of sustainable development to undergraduate engineering students was everyone's responsibility. They include the academicians, the members of the university management, students and the university community as a whole. Said U3, *now all lecturers including vice chancellor and anybody or everybody who is part of the university community everybody and the students themselves must be part of it, that's what I believe* (U3, lines 1081-1083).

Industry practitioners were in favour of engineering and non-engineering academicians teaching sustainable development. IP4 for example, explained that the non-engineering academicians would complement the engineering academicians in their efforts to teach sustainability. IP3 said that it should be the responsibility of both groups of academicians to teach sustainability at the university. He said, *everybody can do it, sustainability is not for engineers alone* (IP3, lines 475-479).

Interviews indicate that it was beneficial to include non-engineering dimensions of sustainable development in the undergraduate engineering programme. IP4 commented that life cycle costing was an essential business dimension in sustainable engineering. S3 on the other hand said that critical thinking and reflective thinking were apt non-engineering dimensions to include.

> *I, as I mentioned just now, the reflective process is based on non-engineering courses, so maybe the non-engineering lectures will take of the, reflective process, the critical thinking, and while the engineering lecturers they're more into the technical features* (S3, lines 638-640)

S5 nevertheless commented that the inclusion of non-engineering dimensions would be advantages, especially in research based modules, as it would enable engineering students to look at the bigger picture.

> *when I go to internship, I can see that those things are taken into the consideration, but when we are doing out ETP or FYP we are only considering technical parts. ...So when, maybe if we can incorporate into our ETP we can get more experience, we can think in a broader perspective.*
>
> (S5, lines 114-120)

Methods of providing sustainable development input

A2 and EP5 said that sustainable development input it should be provided to students at the first year of their undergraduate studies. A1 on the other hand was of the view that sustainable development input too early in the undergraduate engineering programme could be a setback as students may not be mature enough to make the relevant connections between sustainability and their future careers as engineers.

EP7 said case studies were a powerful means of providing engineering students with sustainable development input. He explained, *...case studies is really very powerful I think you know giving ideas as well I talked to so and so some person in engineering and whatever you know this is what they do so that kind of things make it concrete* (EP7, lines 320-322).

A3 stated that adjunct lecture sessions were another manner in which sustainable development input could be provided to undergraduate engineering students. EP1 however disagreed with this approach, given the fact that it was not as effective as engineering and non-engineering academicians getting together to teach a sustainable development module. Additionally, EP1 also explained that adjunct lectures could also be a barrier. This was due to the fact that adjunct lecturers would need to be made aware of the module, its objectives and the manner in which the adjunct lecture session should be incorporated within the module, before the actual session takes place.

Philosophies and styles of teaching & learning for sustainable development

Academicians indicated a variety of ways in which they try to be relevant to the engineering students they teach. A5 for instance says that her students prefer academicians who are entertaining. *I think they do like they prefer the lecturer is entertaining … yeah they prefer if we were entertaining them* (A5, lines 151-152), she commented.

A6 said that he tries to be interactive in class, but has observed that his students are either shy to respond, do not want to respond or do not understand what he has taught them. He said that exercises are given to get the students to interact more. He also explained that the level of interaction practiced was dependent upon the module he taught.

> *I try myself to have interaction with the students lah but sometimes I face difficulty because the student sometime no respond [right] ya kan, they no respond , they very shy to respond or they don't understand what I'm talking lah and the later part is more worrying lah*
>
> (A6, lines 192-196)

The interactive approach practiced by these non-engineering academicians seemed to have proven to bear fruits, as S1 indicated that non-engineering lecturers were more fun than their engineering academicians. *Fun part. Yeah. It's always fun to listen to non-engineering lecturer teach. Seriously* (S1, line 359) said S1. However, S3 was in support of her civil engineering lecturers. She observed that there were no barriers between the civil engineering lecturers and the civil engineering undergraduate students. She also commented that while her civil engineering lecturers encouraged active learning through project based tasks, this was not the case for non-project based modules taught in the undergraduate civil engineering programme.

Interviews indicate that engineering and non-engineering academicians were open to two way communication with their students during lessons, with many of them claiming to practice this approach while they teach. Non-engineering academician A5 was one of them who said she goes for two way communication. Similarly, A9 said that as a young lecturer, it was necessary for her to use this approach in class to be more appealing to the students she taught.

> *…we needs two ways communication right in University X we apply OBE okay we don't want to produce* self-centred *.. and one way traffic.. communication because I apply two ways communication, I'll be asking direct what direct evaluation that you can see if whether they understand or not*
>
> (A9, lines 164-169)

Engineering academician A10 explained that he tries to encourage two way communication during his lessons. A2 however stated that two way communications was ideal but it was not possible because students had to be forced to talk, which he does by asking them questions about the lecture. He commented, *You have to force their mouth to talk. You have to make them talk. and the way I make to talk is ask questions yes, you should come to my class.. they are forced to talk, every single one of them in the class* (S2, lines 289-292).

While academicians claimed to practice two way communication, final year undergraduate engineering students surprisingly observed otherwise. S2 for example explained that one way or two way communication during lectures depended on the type of lesson for the day. Theoretically based lectures were mostly one way, but there were academicians who did ask students questions during the lectures. S2 additionally commented that engineering modules were mostly thought using one way communication rather than two ways. S5 also agreed with S2. She said academicians she had encountered during her years of studies in the university were mostly one way communicators. Said S5, *It depends on the lecturer, some are two way, but mostly in University X is one way* (S5, line 197).

Several limitations to the teaching of sustainable development were revealed during the interviews. A8 described the sustainable development perspective of the engineering programmes as narrow as teaching was focused upon natural resources. The approach taken by the engineering programme modules differed from the approach non-engineering modules take. *... so those engineering people are only looking at the concept of sustainability in terms of usage of natural resources okay so that's a difference* (A8, lines 287-302), stressed the respondent.

A5 stated that the modules offered by the department of Management and Humanities were not tailored to meet the engineering programme's sustainability outcomes. Although it may be on paper, she explained that it was not practiced in reality. Surprisingly though, U4 said that it was necessary for sustainability to be included in all modules taught by academicians in the department, indicating an apparent mismatch in the manner in which the inclusion of sustainability within teaching practices has been perceived by academicians in his department.

> *So far, it has been that way, only whether it has been written as sustainable development or not. Alright, so, some engineering, I know engineering programs they have explicitly mention sustainable. For this department, you may have it for some courses you may not have it, but you may state it. It goes like you know by convention you know it should be there.*
>
> (U4, lines 52-58)

Interestingly, final year undergraduate engineering student, S5 commented that throughout her years of studies at the university, she had not been exposed to the teaching of sustainable development in the engineering and non-engineering modules she has taken. S5 explained that her exposure to sustainability was primarily through her internship experience and her own initiative as a learner.

> *I would say that those courses is very technical, and maybe before my internship I don't know how am I going to apply this, now that I'm doing my final year project, when I did my literature review for my FYP, I would say that there is a lot of impact towards sustainable development… and it has contributed to my sustainable development knowledge*
>
> (S5, lines 65-70)

Academicians also cited students approach towards learning as a limitation to proceeding forth with the teaching of sustainable development. A6 for instance was concerned that his students were shy to respond to him during lessons. Similarly, A6 said he had to force his students to answer the questions he posed to them during his teaching sessions. A6 also said students lacked the ability to think critically, and blamed it on the spoon feeding approach students were so used to. U3 who had similar views said that students were not given enough opportunities to be critical thinkers. He commented that the pre-university experience they received could be a possible reason for this limitation.

EP 1 reiterated the importance for students to ask questions, and not be passive listeners. He nevertheless cautioned that this could be difficult and intimidating for them. He noted, *it's much more important for students to ask question than to sit and listen, I guess it's hard, can be intimidating* (EP1, lines 264-265). U3 also explained that while the students could be sound theoretically, they lacked practical soundness. He traced this limitation to the manner in which students were cultivated to learn during their primary and secondary education. This as a result caused them to struggle academically at the university. He asserted, *It's not in the education per say it's not a total learning process , ... the students, they just read but they cannot relate it to the actual* (U3, lines 103-108).

Assessment is an essential component in the teaching of sustainable development, which academicians lacked much awareness in. A9 for instance raised the concern on the manner in which sustainable development is to be assessed and saw it is a challenging process. EP8 and EP4 provided pointers on approaches academicians could think about when assessing sustainability in the modules they taught. EP4 said it would be more beneficial to assess sustainable development through the evaluation of a project, rather than through examinations. Explained E4, *In engineering courses you got to test and assess so many things…So for you to test that, it's got to be an entire project with that being one of its main goals. It's to test that ability* (EP4, lines 603-616). EP8 on the other hand explained that the assessment of sustainable development could be attempted through components such as awareness, techniques and knowledge. He said, *Ahh, sometimes we normally judge education courses on awareness, techniques, knowledge… So for me I'd say you judge the education course on sustainability with reference to those sort of criteria* (EP8, lines 524-529).

Academicians and final year undergraduate engineering students indicated that present teaching philosophies in the university were not very sustainable. A4 for instance was concerned with the mass lecture approach the university subscribed to in handling large student numbers in common engineering modules. For A4, such an approach not only stifled innovate teaching, but also encouraged conventional teaching methods.

> *…first and foremost I would look at the numbers, … where where it is a mass so, of course it is impossible for you yes, for you to a little more innovative, for instance, because of the head counts the somehow the delivery is still conventional* (A4, lines 211-215)

U4 meanwhile explained that there was no structured approach to the inclusion of sustainable development input in common non-engineering modules offered by the department of management and humanities. As a result, such input was either provided directly or indirectly, he said.

S4 described his four year learning experience in the undergraduate engineering programme as more focused upon theoretical elements rather than practical elements. He also said that academicians practiced one way communication rather than making it two ways. A reason for this could be the fact that the university does not have a *clear cut direction* (U3, line 996) that specifically stipulates the teaching philosophy academicians need to adopt for teaching at the undergraduate engineering programme.

Benefits and challenges to academicians in relation to ways of approaching the teaching of sustainable development and placing sustainable development in the curriculum

Respondents indicated various challenges in light of the issues to consider in approaching the teaching of sustainable development and the placement of sustainability content in the undergraduate engineering curriculum. A5 said the main issue to consider would be time. She said she hardly has the time to complete her existing syllabus at present.

> *It's not in the component we hardly have time to finish our syllabus so when are we going to make the connections to put it up, unless the topic somehow triggers you to talk about the environment, talk about what's gonna happen to all of us in about 10 years , 20 years, other than that no, don't know* (A5, lines 650-653)

A6 commented that the inability of academicians to relate research to teaching is another issue that could hamper the inclusion of sustainability in the curriculum. Using his own module as an example, he said *…Oh, definitely...but whether, how that relate to sustainability I'm not very sure lah* (A6, lines 67-75). A8 was concerned about the undergraduate engineering students' lack of exposure to ethics. A8 was of the opinion that the ethics component should be included in all undergraduate engineering modules. Interestingly, A2 stated that the undergraduate engineering curriculum and governmental enforcement related to sustainability was disjointed, resulting in laws that are not stringent.

> *...i think in the main problem is not with the curriculum but it's more with the.. our present system… that's a main problem, in curriculum aspect I think we are preparing the students but when they go out there they will not be how do I say...they cannot implement because the laws are not stringent enough*
>
> (A2, lines 57-75)

A3 was concerned about the position of sustainable development as a programme educational objective and its pedagogical impact upon the undergraduate engineering curriculum. She said that although sustainable development was a programme educational objective of the mechanical engineering programme, which was covered at the level of understanding, it was not a tested component. As a result, students do not bother to study sustainable development in depth.

> *…it is in our programme objectives, the programme outcomes but whether the students are going to study or not they will ask the same question is that covered there so when you say no they're not going to study so it's very difficult to..unless we have a special subject that is compulsory to students that sustainability development this kind of things then they will have to study*
>
> (A3, lines 106-121)

A1 reiterated that it was difficult to relate sustainability in modules that were technical in nature in the undergraduate chemical engineering programme. This therefore resulted in many academicians not including sustainable development content in the modules they taught, including him, as he is afraid it would confuse students.

> *... I would say only about 20% the courses under chemical engineering will talk about something like sustainability but other courses which are... are too technical... too confined to certain areas they don't go to the the the... broader spectrum of talking the the..talking about the.. the.... the wholeness of the whole problem* (A1, lines 38-45)

A10 had a similar opinion to A1 on relating sustainability to modules offered at the electrical and electronics engineering programme. He said it would be difficult to relate sustainable development content in electronics based modules. EP4 was of the opinion that the more generic a sustainable development module was, the more difficult it would be to make it interesting.

> *So then, I have to go to generic courses of sustainability which is about everything and the more general you make it, the more challenging it is on the module to make really interesting. Because generic you call soft subjects and they are very ineffective and lose students interest very quickly unless very well taught. So you've got this tension and again the lack of focus. Focus issue. Where it is just a matter of scale for it being better as a module or better as a part of the subject. And you got that against the philosophy of generic aspect, which is students don't tend to like and more challenging for the lecturers.* (EP4, lines 333-340)

Academicians and members of the university management had mixed views on the best method to integrate sustainability within the undergraduate engineering curriculum. A8 for instance was not agreeable to making sustainable development a module on its own as she said it would be a duplication of other modules that may already have sustainable development input as part of its module content. A3 however thought it would be a good idea to make it a compulsory module in the undergraduate engineering programme as it will force the students to be exposed to sustainability.

> *... if you have this as one subject alone that will be good because from the current trend we're looking for all the sustainability so this students besides getting their engineering fundamental they should have known what is this sustainable development...if you have one extra subject I don't know where to put in but it is definitely good*
>
> (A3, lines 125-133)

Nevertheless, she also said that an extra module would translate to additional credit hours, making the total number of credits students had to complete increase. A6 was of the opinion that sustainable development can be offered as a module on its own to enable in-depth delivery of sustainability content. He also suggested that the module should be provided early in the undergraduate programme to lay the foundations of sustainability. A7 also said that making it a separate compulsory module would be more effective than including sustainable development content in all undergraduate engineering modules, so it will not be overlooked.

A2 and U2 were also in agreement of making sustainable development a university requirement module, and also included in all modules across the undergraduate engineering curriculum. A2 said that *instead of co- curriculum we just put sustainable development* (line 427) to replace the second co-curricula module students had to take as part of their total credits for the undergraduate engineering programme. U2 meanwhile insisted that the module be taught by competent academicians, and should be multidisciplinary in nature.

U3 and A2 however were of the notion that sustainable development could not be taught as a university requirement module. According to A2, sustainability should be something students had to learn on the go. He also added that sustainable development was viewed differently by the different engineering disciplines and thus having it as a university module was unsuitable.

> *…the sustainability aspect is something that want us to learn on the go it's not that want us to stop and learn and go and there's no point in wasting one course on the sustainability aspects. This is something that as I said it has to build in in your blood* (A2, lines 281-285)

Industry practitioner IP4 was of the opinion that sustainable development should be taught as a stand-alone module to send a clear message to undergraduate engineering students that it was important. He also said it was necessary to include sustainable development content in all undergraduate modules in addition to this teaching it as a separate module.

> *I think that should be one stand-alone course and some courses that should be integrated to create that long term long term edu learning process, yeah ...one one course stand alone because we are sending a message clear that this are important and the rest*

must be in area where can be prescribed where sustainability is important

(IP4, lines 385-389)

IP3 also stated that it was necessary to make sustainable development a compulsory module in the undergraduate engineering curriculum to create engineering students awareness of sustainability. He also said that it should be made a requirement in the students' final year engineering projects and final year reports or thesis.

> *Okay.. one idea.. it could be one paper , okay one subject ,but i know that's not going to help much because students will try to memorize and try to pass the paper , another approach if we don't want to do that we integrate all their thesis work or project work with sustainable activities*
>
> (IP3, lines 455-457)

IP6 on the other hand said that sustainable development content should be made compulsory in internship reports submitted by students. He noted, *You could require, I don't know after internship does the students have to make, make a report or write, you could require the sustainability section of that* (IP6, lines 374-375).

EP3 said that sustainable development should be offered as common undergraduate engineering module. He also proposed for it to be offered as a joint degree, jointly offered by the engineering programme and the department of management and humanities.

> *...there could be a common course on sustainability sciences to be offered to every student in the university second is that perhaps coming from this department or from joint …where you you combine of other few areas and you produce this … a course of university, one and another course where this would come from this department* (department of management and humanities) *and would be good for a start*
>
> (EP3, lines 195-205)

Final year undergraduate engineering student S2 was of the opinion that sustainable development should be an elective module, *because no... too many things in engineering* (S2, lines 457-464). S5 said that having sustainable development included in all undergraduate engineering modules would be good.

However she commented that it would be more effective if was made a compulsory module so it would be more impactful on the engineering students.S5 also said that the assessment of sustainability should be through coursework alone. Teaching approaches should not be conventional lecture based sessions, but should instead use case studies and be project based, S5 added.

> *I think if we integrate it it should be nice, but if we have one course specifically for sustainable development then we can cover all aspect...And when that course is compulsory, everyone would have to take it and it will give a much more bigger impact to them, and that cause students to be too strict maybe have a different approach to teaching it, not just using slides, maybe a case study discussion, a project that students can come up with ideas*
>
> (S5, lines 167-170)

S1 was of the opinion that sustainable development should be made a component of all undergraduate engineering modules to ensure continuity. S3 on the other hand commented that sustainable development should be included in selected engineering modules which could be related to sustainability easily. She stated that if sustainable development content were to be included in non-engineering modules, it should be approached from a reflective angle.

Dealing with sustainable development content

EP1 explained that every module would have some element of sustainable development in it. Thus, it is inaccurate for academicians to claim that there is no sustainable development element in the modules they teach. He said, *I think with every, with every module there is a sustainability criteria, whether it's social, economic, ecological, environmental, ethical and I don't think you can ever say my course has nothing to do with sustainability* (EP1, lines 294-296). EP1 further commented that academicians can use context rich issues to discuss sustainability. EP5 on the other hand stated that once sustainable development is included in the curriculum, it becomes one with the academician and will become more familiar to them as they continue to teach it.

U4 explained that the diversity of the modules offered by the Department of Management and Humanities made it difficult for sustainable development to be embedded in all the modules. He further explained that if it had already been embedded in the modules, it would most likely be a 'second tier' element.

> *... we on our side, management humanities, we pick up from there uh, if you, for example, if you're from finance, you only do the numbers, how you translate what they have proposed for sustainable development into dollars and cents, if you are from economics, once again you take up what they propose and uh, work out in such a manner that its economically viable, alright, so basically, we tend to be on the second tier...*
>
> (U4, lines 24-32)

U4 also said that while the undergraduate engineering programmes had explicit programme outcomes related to sustainable development, modules offered in the management and humanities did not have such outcomes. This was because the department does not offer any undergraduate programmes, and was thus not obliged to the same conditions to include sustainable development outcomes as imposed on undergraduate engineering programmes.

EP5 suggested that sustainable development could be added on as a common theme in undergraduate engineering modules. He said, *because it needs to be built in such a way that can be disassembled, etc. so those things i think what, what. I guess therefore the way we are dealing with things here, is is by adding sustainability in as a what you might call a common theme* (EP5, lines 155-157). EP7 on the other hand provided examples of issues that academicians could incorporate in undergraduate engineering modules. These include energy policies development, bio-mass or bio-fuels and how it is applied, bio-energy and the role of corporations in relation to sustainability.

Defining holistic understanding of sustainable development or sustainable engineering

Being an academician, A4 viewed the term 'holistic' as the advancement of sustainability which encompassed environmental, economic and social aspects. IP4, an engineering industry practitioner said a holistic approach from the perspective of the engineering industry, was to include sustainability in engineering practices from human and social dimensions. He explained, *Holistic is looking at it from non-engineering perspectives, the humanities angle, the social angle* (IP4, lines 494-495). EP6, an ESD practitioner said that holistic can encompass teaching and learning, the student experience, thinking at module level and programme in whole.

> *Holistic... well I think the big H is thinking about the teaching and learning and the student experience all in one its thinking not only module of level course that's what we tend to do on teaching, I'm teaching this for 10 weeks , then it's over , thinking about the links , its thinking a programme level in whole*
>
> (EP6, lines 391-394)

The university-internship-workplace ties in relation to sustainable development

A9 was of the opinion that the university experience, the internship experience and the workplace had individual roles to play in developing undergraduate engineering students' awareness of sustainable development. IP4 and IP6 were of a perspective similar to A9. IP4 however emphasised that while all three entities were important, the university had a greatest role of the three, as it was the starting point to inculcate this awareness in engineering students. IP4 also commented that employers expected their engineers to work with existing knowledge on sustainability, and not come into the workplace to learn about it.

> *it's all linked but it has to come from there. The university itself. That is the starting point. You know after they finish the, they need to learn something. For them, say new graduates come it's not learning for them, you know.*
>
> (IP2, lines 1397-1399)

A7 however stated that the internship experience enhances engineering students' exposure to sustainable development. This view was in congruence with the views of the final year students. S4 for example said that his exposure to sustainable development was gained through his internship experience. Similarly, S1 said that his internship experience provided him with the exposure to technical perspectives of sustainability, but not some much on humanities, social sciences, and communication aspects related to sustainability.

> *Yes during my internship here, I can see clearly that sustainable development is one of the very huge aspect there...there is few elements in there that we engineers must do. We need to tell the community on what are the impact of the things we do to them. How the thing will affect the environment, we also need to communicate with them, we also need to be aware of what are we going to do.* (S1, lines 68-87)

S5 also agreed that her internship experience provided her with awareness related to sustainable development. She also attributed her final year undergraduate engineering research topic in helping her obtain more awareness on sustainable development.

Surprisingly, IP4 was of the opinion that the internship experience was not a suitable avenue for sustainable development exposure as it was a short stint. As student were dispersed across many industries, it was difficult to develop competences related to sustainability, said IP4. He explained, *It will be difficult because internship role itself is quite fast , I don't think they have enough time, to do that and students are placed displaced everywhere you know, it's quite difficult* (IP4, lines 394-395). To counter this setback, IP4 suggested that students be placed for internship exercises in organizations that were practicing sustainable development and sustainable engineering.

IP2 emphasised that it was necessary for the university to include a sustainable development component in the internship exercise. As stated by IP4, IP2 also said it was essential to send engineering students to organizations that practice sustainability. IP2 further commented that it was necessary for the university and industry to have more dialogue sessions and collaborations to encourage awareness on sustainable development. IP1 said that the university and internship exercise should advance for sustainable development awareness to be approached from a holistic perspective.

The place of sustainability in the higher education context

Interviews revealed that there were present limitations within the Malaysian education system that need to be addressed. One of the limitations cited was the continuity between secondary and higher education policies in related to outcome based education. U3 explained that the outcome based education system practiced in the higher education system for engineering programmes was not practised at the secondary level. Said U3, *you know I give examples, at university level using OBE, at school level are we using OBE? No you see so there's no continuity* (U3, lines 151-152). U3 further mentioned that it was not right to adopt a foreign education model like the outcome based education model into the Malaysian education system. Instead, a model unique to the Malaysian higher education system should be developed to advance engineering education in Malaysia.

EP1 explained that sustainable development should be very prominent in the higher education context, as there was a need to develop a new kind of conscious in higher education, which is presently lacking. EP1 likened the university to an incubator for innovation, teaching, learning and research in the context of sustainability.

> *sustainability... and moving towards sustainability is the key challenge of time, the entire higher education is very privileged place where people have time to study to think to reflect to read to see multiply and to come up with new ideas , so it's an incubator place for innovation and higher learning, so it should one of the places or the place where a teaching learning research in the context of sustainability is done, you could say, we need to develop a new kind of conscious in higher education… I think given the stay on the planet we need to have other obligations the moral obligation and universities to develop the students and more faculties...a kind of awareness of what graduates do or can do to move into sustainability*
>
> (EP1, lines 28-37)

He also commented that universities have to ensure that transdisciplinarity and systems thinking are interlocked to advance sustainability within higher education.

Sustainability and the Malaysian engineering industry

Interviews with industry practitioners revealed interesting findings on current sustainable development practices within the Malaysian engineering industry. These findings provide essential pointers for universities to take heed of, in preparing their undergraduate engineering students for the engineering workforce. IP2 explained that sustainable development was a major requirement for engineering based businesses worldwide. He cited his multinational engineering organization as an example, in which potential vendors are first screened for sustainability credentials before being decided upon to render their services to his organization. IP2 also said that large scale multinational engineering companies in Malaysia focused on sustainable development practices and policies to compete in the industry as sustainability credentials are seen as an asset for a company to have. IP6, echoing similar sentiments, explained that engineering organizations with sustainability certification were rated higher when seeking ISO certification. IP4 on the other hand explained that Malaysian consumers find sustainable engineering an expensive investment, even with the government's provision of tax incentives for green projects. IP4 also said that it was difficult to convince clients on the need to be sustainable. This in turn made the implementation of sustainable engineering practices a complex undertaking.

Interviews revealed that engineering industry practitioners were worried about the level of enforcement of sustainable development policies and practices in the country, based on their experiences dealing with ISO certification for energy management systems for their organizations. IP3 also said that the country was not fully emphasizing the need to practice sustainable development, even though it has a specific ministry in charge of such initiatives. This made sustainability seem trivial, and spoken of for the sake of protocol.

> *but in Malaysia, sustainability itself is not being emphasised anywhere , okay I don't know about universities but I think the government themselves are not emphasizing this although they have a minister.. they have a ministry*
>
> (IP3 lines 71-74)

IP2 on the other hand mentioned that while there were energy policies in place, it is not practiced in full force as it should. *They have all the policies, all the acts but they don't practice it* (IP2, lines 396-397), he said.

These concerns suggest that sustainability related dialogues and negotiations with the authorities form an important component of an engineer's work scope. As such, universities must take measures to ensure that their undergraduate engineering students are provided more awareness and training in these areas. This would train the engineering students to be better equipped with the knowledge and skills needed to carry out discussions with authorities on matters pertaining to energy management and sustainable development policies and practices within the engineering industry.

Interviews with industry practitioners revealed alarming gaps in the desired sustainability competences required by the engineering industry of their engineers, and the actual level of sustainability competences engineering students are equipped with when they graduate from their undergraduate engineering programmes. IP2 explained that the engineering industry was in need of engineers who understood measures such as retaining and improving, safety as well as energy conservation. He also emphasised the need for engineering graduates to be able to think of the implications of the technology they purchase.

IP4 explained that universities need to tailor their engineering students' exposure to sustainable development in line with the needs of the industry. At present however, IP4 explained that engineering graduates may not be able to practice what they have learnt in the university, as the industry may no longer be practising the outdated sustainability policies and practices the graduates were exposed to in the university. IP4 also stated that it should be the younger pool of engineers who should promote the need to make the change to sustainable engineering practices. This was based on his observation of the older generation of engineers who were not so inclined to change their old engineering practices.

> *but I think it's rightfully pointed teaching the young people now, it's true, because the old fellows, you cannot change anymore. So I think this young young flock of engineer coming up, they will eventually change unless which they have to change the landscape, of the you know, Malaysian engineering concept for sustainability* (IP4, lines 79-82)

IP4 also said that engineers should move away from tending to only focus on singular perspectives of engineering. He also noted the importance of engineers being trained to think economically as well as using common sense to solve engineering problems.

> *because engineers sometimes they look at one straight one straight way , most engineers look at it like this ... hey if I use this material you know, sustainable material how much it cost uh for a project? that's what they ask you know , they stop of asking what are the benefit you can in a long term during the duration of the build.. the life of the the building, they never ask the question , they said how much it cost , if they go beyond that,*

> *hey, what is the benefit full stop. Ow the benefit is insulation properties are higher, we save some energy, ow okay that's good that's good that's all. they never ask long term what kind of impact there is , so that's here in Malaysia the engineers here are not trained to think economical in terms of common sense, not so much there* (IP4, lines 280-288)

Industry practitioners also commented on the quality of engineers who have recently graduated from Malaysian engineering universities. It appears that Malaysian engineering graduates have a lot to improve upon if they were to be employed by the industry. IP3 observed that engineering graduates lacked the skills to analyse the long-term effects of sustainable engineering and sustainability. IP2, IP3 and IP6 observed that Malaysian engineering graduates lacked self-awareness and knowledge of sustainable development. As a result, many of the engineers had to be re-trained as they had no knowledge of the sustainable engineering practices the engineering industry upheld. IP2 also said that engineering graduates had a take for granted attitude, do not communicate much with superiors and colleagues on issues pertaining to work or offer views and had to be forced to offer their views. IP6, who had similar views with IP2 said that engineering graduates need to have the right attitude to sustainability when they work.

> *The main thing is to learn. To learn you can, there's, there's been a little bit of tendency in Malaysia, you have to memorise bits. The concern is really that you learn to learn. So in this case it's more that awareness about sustainability to make sure the students, they have the right attitude towards this when they start working.*
>
> (IP6, lines 67-71)

Shaping higher education for sustainability nurturing

U3 explained that the addition of the sustainable development component in Malaysian undergraduate engineering programmes were unclear. U3 said that the university merely added in the sustainable development component to comply with the requirements of the Engineering Accreditation Council. He further said that the Engineering Accreditation Council does not address the engineering curriculum as a whole, as the outcome based education approach was added in to conform to the Washington Accord. U3 also commented that it was necessary for the Engineering Accreditation Council to ensure that sustainable development was thoroughly implemented in universities offering engineering degrees.

> *…Why we we you see , this is where we have to comply to the departments so we are doing it just for the sake of doing it I guess, whether it is really going to work or not that we have to see lah*
>
> (U3, lines 333-339)

IP4 on the other hand said that the Ministry of Higher Education was not engaging enough with the engineering industry. IP4 also commented that the Malaysian engineering education system was not developing sustainability competent students, but sustainability aware students. *… I think we are also equally guilty because we don't have the real things for them to you know to consider as sustainable* (IP4, lines 167-178), he said. IP6 was of the opinion that the Malaysian engineering education system should address the bigger picture when it comes to sustainable development, i.e. what it is for, what good it is for the individual and for the organization. He said, *I think everybody's interested. You just have to sort of, to explain the bigger picture, why are we doing this, what, what good is it for you, what good is it for the company and for the community and so to speak* (IP6, lines 135-137).

U3 explained that there was a need to re-look the overall teaching and learning process, the present engineering curriculum and the nation's needs. He further added that imposing a foreign education model such as the outcome based model as a quick solve method was inappropriate as such an initiative needed a long-term solution to make it more sustainable. *No, you see, so there's no continuity, you know they should not pump a foreign model into our education system OBE is a foreign model* (U3, lines 152-153), said U3.

IP4 commented that the university must ensure that a large number of their engineering academicians have professional engineering qualifications. IP4 also said that the present academic curriculum of engineering programmes lacked commercial value. This was because 99% of the engineering research produced by universities could not be patented. IP4 explained that this gap could be addressed by inviting industry practitioners to review the research. He said, *when you have an exhibition right, since I always attend this exhibition when I was a consultant before we attended so many educational exhibition, you find that almost 99.9% cannot be commercialised* (IP4, lines 206-208). IP4 further said that universities should look into enhancing the practical content in the engineering curriculum. This could be achieved by inviting industry practitioners to assist them with the enhancement of the engineering programmes offered. *I think, well I think the curriculum is correct, the curriculum we have here is good, except for the practical aspect there's where their lacking* (IP4, lines 293-294), he explained.

Respondents suggested useful ways in which sustainable development gaps could be addressed in the curriculum. IP4 for instance was of the opinion that the university had to decide upon the sustainable development angle it wished to focus upon, instead of just adding in the term to the programme outcomes because it was instructed to do so by the engineering Accreditation Council. IP2 said energy and safety were issues that should be focused upon in the undergraduate engineering curriculum. He further added that the ability to think sustainably and to look at the bigger picture were issues that should be emphasised. IP3 on the other hand commented that universities should do away with being examinations focused, but should instead focus on the individual development of its engineering students.

EP1 explained that there was a need for universities to allow students to specialize in being able to see connections and interpret, sympathize and think critically on choices that individuals make. As such, the university curriculum should be real world issues driven and participatory in nature. Universities could also do more for the community by inviting them to drop in problems for the university to find solutions to as part its outreach initiative. These projects can be worked upon by academicians and students. EP1 also commented on the need for the curriculum to provide space for dialogue, negotiation and ownership. EP3 was of the opinion that higher education itself should embody sustainability. As such sustainable development initiatives should not only be limited to the curriculum content, but also to the campus environment, sociological aspects, cultural aspects as well as organizational aspects and these should in turn be imbued within the undergraduate engineering curriculum.

> *higher education has to conceptualize and define reading to the individual to the parties concern. Here it's the student and the lecturers. Higher education itself is sustainability, be ..should be objectivise sustainable venture, not only in regard to the content also regard to the campus environment and one has to look at beyond the campus in order to sustain sustainability it would mean the the the sociological aspect, the cultural aspects human memory you know organisation heritage so there's the average of this theme and must be imbued in the curriculum itself*
>
> (EP3, lines 26-32)

EP6 explained that sustainable development should be about the subject, the pedagogy, processes, values and enforcement. EP6 also explained that the voice of students was an important element in bringing forth the sustainable development agenda.

> *sustainability is about the subject it's about the academic content it's about the science , it is also about pedagogy its hugely about methods of teaching and learning , engagement with the students it's about university processes it's about thinking about what are we looking for when we are improving new courses and modules what do we looking when we recruiting staffs so its subject , its pedagogy , its process and its values*
>
> (EP6, lines 61-65)

EP1 explained that it was necessary to get all stakeholders of the university to jointly create or develop notions of what sustainable development is to them, to obtain a common agreement of the term. This would ensure that sustainable development does not become a puzzlement and had some value and meaning to it. EP6's views were congruent to the views of EP1. She said that the university management played a vital role in advocating for sustainable development as a common vision binding the stakeholders of the university. She further commented that the strength of sustainability lied in the getting the university community as a whole involved. This was apparent when she said *instilling to the whole university community this is absolutely top priority* (EP6, lines 217-218). EP6 also said it would be necessary to recruit staff with sustainable development qualifications and get all academicians to complete a postgraduate certification in sustainability to ensure a common vision of sustainability is understood. EP1 additionally cautioned that dictating or forcing sustainable development onto policies and practices was a recipe for failure. EP1 also stressed the need for a sustainable development champion who could help get the cynics and sceptics on board.

> *...try to get all this stake holders and try to jointly create this developed issue, what's needed also have some discussion among the stake holder what is sustainability mean to you, you need to bring everybody involved on board… I think it inspirational examples, motivational speaker, a champion you know who could do that would help those who are cynical sceptical get on board as well*
>
> (EP1, lines 158-175)

6.10 Discussion of key findings

The key findings of Research Question 2d revealed interesting perspectives from stakeholders on the manner in which sustainable development and ESD competences should be included within the curriculum. The findings are discussed in the paragraphs that follow.

The sustainable development module

The survey conducted indicates that the undergraduate engineering students were not in favour of a stand-alone engineering module or non-engineering module within the undergraduate engineering programme. Findings from academicians and industry practitioners however suggest otherwise, as there were suggestions for such a module to not only be made a common compulsory university module, but also included as a component in all undergraduate engineering modules across all engineering programmes in the university. Academicians even suggested replacing a co-curricular module in the present undergraduate engineering curriculum with the sustainable development module. There were nevertheless academicians against making the idea of making the module compulsory, as they were of the notion that sustainable development should be learnt on the go. Having the module as a common university requirement module was also seen to be unsuitable, due to the various ways in which sustainability is viewed by the different fields of engineering.

Student stakeholders disagreed that sustainable development input should solely be obtained from the engineering or non-engineering modules offered in the undergraduate programme. Students were in support of the university providing sustainable development input through all undergraduate engineering modules, be it an engineering, non-engineering, common, elective or compulsory module. Although students have unconsciously recognized and endorsed transformative approaches through multi and transdisciplinary approaches to the teaching and learning of sustainable development, academicians were not too convinced. Academicians said a compulsory module would force the undergraduate engineering students to learn about sustainability, and would enable in-depth coverage of sustainable development, in comparison to having it covered within all undergraduate modules within a limited scope. The findings of the present study bear similarities with the findings of the study conducted by Drayson et al (2011), where findings of a national online survey they conducted suggest that first and second year higher education students preferred for sustainable development content to be reframed within the existing curriculum, in comparison to making it an additional module within the curriculum.

In tandem with the principles of transformative pedagogy, a multidisciplinary angle was said to be the best way to develop the contents of the module. This perspective was also recommended by ESD practitioners. The importance of a multidisciplinary sustainable development perspective was also emphasised in studies conducted by Bryce et al (2004), Moore (2005), Valazquez et al (2006), Mulder and Jansen (2006) and Lozano (2010).

Students were also of the view that both engineering and non-engineering academicians should teach sustainable development related content. These findings corroborated with findings of the interview which also reveal that the engineering and non-engineering academician team up was the best approach to teach sustainable development. Interestingly, students also believed that sustainability should only be taught to them after they have obtained a strong foundation of the engineering modules and not during their first year of studies in the undergraduate engineering programme. There were similar and contrasting viewpoints from academicians and ESD practitioners on this issue. While some academicians were for the teaching of sustainable development during the first year of studies, others were against this, stating student would not be mature enough to make the relevant connections between engineering and sustainable development. Industry practitioners on the other hand suggested that it would also be essential to add sustainable development as a required component in engineering students' final year projects and internship reports.

Given these various limitations, a possible recommendation would thus be to make the module a compulsory common module for first year undergraduate students. The rationale of doing so would be to provide a fundamental understanding of sustainable development to the undergraduate students from a broad perspective, namely from of the points of view of the various engineering programmes offered in the undergraduate programme, as well as from non-engineering perspectives, such as management and business, language and communication and social science and humanities aspects.

In addition to providing students with fundamental understanding of what sustainable development entails, the university could also approach sustainability from the perspective of the engineering domains offered at the university. These modules should also be made compulsory modules within the curriculum of these specific engineering programmes, and tailored to reflect sustainable engineering and its impact upon the environment, society and economy. As a third suggestion, it is also proposed that the university develop a sustainable development module from a purely non-engineering perspective. This module could be offered as an elective module under the Department of Management and Humanities. The rationale of developing this module is to provide the engineering students with an understanding of the impact of non-engineering areas such as education, history, the arts, geography, business and politics on sustainability and its relation the environment, society and economy.

Teaching and learning issues to be considered for the inclusion of sustainable development within the undergraduate engineering programme

Open-ended responses from the student stakeholder survey indicated pedagogical issues undergraduate engineering students thought should be looked into, in relation to the inclusion of sustainable development in the undergraduate engineering programme. These issues encompassed both engineering and non-engineering modules. The open-ended findings for engineering modules show that there was a lack of practical elements in the manner in which modules are taught in the undergraduate engineering programme. It was also found that there was a need to relate theoretical elements taught in the modules to practical and application based activities. Students also revealed the need to include local and global perspectives of real sustainable development issues and situations in the contents of the module. In terms of assessment, it appears that students wanted evaluations to be carried out in a manner that tested their understanding of the concepts, rather than making it examinations calculation and memorization based. Students also wanted to be challenged with real issues faced in the engineering workplace and case studies on current issues surrounding sustainable development or the environment so they could apply their knowledge, problem solving skills, and communication skills to present their own views and ideas on the manner in which solutions could be obtained. These views are consistent with the principles and practices of transformative pedagogy.

The open-ended responses also show that students were in favour of the undergraduate curriculum being tailored to meet the expectations of the engineering industry and their lives, post-graduation. They were also of the view that it was essential that the concept of sustainability and its implication to the future be explained thoroughly through the engineering modules, to ensure they are ready to face challenges they will meet at the workplace and in their everyday dealings with life. Current technological trends and advancements were another issue brought forth by the student stakeholders. It was also found that the undergraduate engineering students wanted their engineering lecturers to expose them to the benefits and challenges of the latest advances in sustainable engineering and sustainable technology to the society and environment. Students were also of the view that that exposure to the engineering industry through field trips, visits, case studies and the use of real technical examples from the industry was necessary for their development of awareness towards sustainable development. These views are again consistent with the principles of EESD, and its absence in the present undergraduate curriculum pedagogical practices is an indication of the eminence of transmissive ideologies within the undergraduate engineering programme. Being attuned to the needs of the engineering industry was a similar finding in the study conducted by Mulder and Jansen (2006), which found the need to engage with the industry an essential organizational issue for universities to consider when integrating sustainable development within engineering education.

In relation to sustainable development content in the present undergraduate learning modules, it was found that there was a need for academicians to make sustainable development more impactful and relevant to the modules they teach as the content of the engineering modules were deemed to be ineffective in developing sustainable development awareness amongst students. There were also recommendations for making sustainable development a learning outcome of engineering modules, to relate social issues with engineering problems and to include an understanding of the various angles in which engineering decisions have to be made to recognize its impact upon the society and the environment. These findings were also seen in studies conducted by Bryce et al (2004) and Scott et al (2012), and are in tandem with the advancement of engineering education for sustainable development.

In approaching the teaching of sustainable development, the final year undergraduate engineering students wanted to see more real world based class discussions, projects, technical and scientific views of sustainability, group based problem solving activities involving students from the various engineering programmes. Case studies were also mentioned by ESD practitioners as an effective method of providing sustainable development input. Adjunct lectures were seen as the least effective. There were also suggestions for academicians to improve on their teaching skills by making lessons more exciting. Students also believed their lecturers should do more to maintain students' interest, to provide more time for self-learning and to relate and place emphasis on the importance of being sustainable engineers.

In relation to pedagogical issues to be addressed in the non-engineering modules, it appears that undergraduate engineering students find communication as an entity to be improved upon in the undergraduate engineering curriculum. The significance of communication in the implementation of sustainable development at universities were also highlighted in the study conducted by Valazquez et al (2005), where it was found that a lack of opportune communication could deter sustainable development initiatives in higher education institutions. The open-ended survey findings indicate that students wanted to be exposed to the role of communication in mitigating appropriate solutions to sustainability issues. It was also found that the Professional Communication Skills module should be improved upon to include skills that could teach students to communicate their ideas on environmental issues to effectively raise greater awareness for sustainability, to communicate with people from other fields and to develop themselves as better engineers. Also suggested was the need to include the development of communication skills through engagement with relevant organizations.

As for the approach for non-engineering academicians to take towards the teaching of sustainable development, students were eager to see academicians take on transformative learning and ESD paradigms through the following means: conducting field trips to selected agencies that deal with issues pertaining to sustainability, sharing past experiences, including an environment theme in the non-engineering modules, making sustainable development a common theme across all undergraduate engineering modules, adding context rich real life sustainability issues and situations in engineering and non-engineering modules, adding practical activities such as dealings with the community and general public, inviting industry personnel to share their experiences, emphasise on practical aspects rather than being too theory based, relating sustainability to the engineering profession, including more group based activities with students from different engineering programmes, adding appreciation of nature and social values in the non-engineering modules and providing students with the opportunity to participate in class based group discussions, presentations, projects and assignments on sustainability related concepts or issues to help promote learning for students and lecturers alike. These suggestions are in line with a number of ESD educator roles and qualities proposed in studies conducted by Jucker (2002, 2004), Wals and Jickling (2002), Welsh and Murray (2003), Dawe et al (2005), Kevany (2007) and Mulder (2009) and Armstrong (2011).

The open-ended survey responses also suggest that the undergraduate engineering students want their non-engineering lecturers to be more aware of sustainable development. These findings suggest that the undergraduate engineering students found their non-engineering academicians to less aware of what sustainable development entailed. It also appears that engineering students want their non-engineering modules to expose them to human and societal aspects of sustainability through an understanding of the social implications of engineering to the world.

Collaborative teaching of sustainable development

Student interviews on the use of collaborative approaches to teaching sustainable development revealed that such forms of teaching would be beneficial to them, as they would be able to tap the expertise their engineering and non- engineering lecturers had to offer. Academicians who were also supportive of the approach to teaching sustainable development collaboratively nevertheless cautioned the importance of synchronizing the topics to be delivered collaboratively. This was to ensure discussions brought forth by the engineering and non-engineering academicians were complementary to each other, and that there were no overlaps of the topic or content being delivered by both group of academicians using this collaborative platform. The findings of the present study are congruent with the findings of the study conducted by Moore (2005), where it was found that the promotion and practice of collaboration across disciplines through teaching and learning were seen to be instrumental in assisting universities in developing ESD programmes.

It was additionally found that the Professional Communication Skills module was an apt platform for the practise of the collaborative approach. Findings show that the technical presentation component of the module would particularly benefit from the collaborative approach, where the engineering academicians could focus on the technical attributes of presentations of this nature, while the non-engineering academicians could help students with the presentation skills necessary to deliver technical presentations. The Engineering Team Project and Final Year Project were other avenues identified as potential platforms of collaborative teaching. These platforms not only provided non-engineering academicians the opportunity to work on multidisciplinary based research with their engineering counterparts, but also enabled them to co-supervise the undergraduate engineering students, in collaboration with the engineering academicians. As the findings suggest that it was difficult for the non-engineering academicians to come across such collaborative opportunities, an effective system must first be put in place to ensure all parties involved in the collaborative process are treated justly.

Communities of Practice

It was also found that the effectiveness of the Community of Practice approach in developing better understanding amongst stakeholders of the university were dependant on readiness. Interviews indicate that non-engineering academicians were reluctant to be a part of the community of practice for several reasons. One of it was due to the fact that they were afraid of the extra effort it entailed in having to read up on sustainable development issues which they viewed as beyond the scope of their expertise. Other reasons were discomfort in supervising sustainable development based research due to the inability to position one’s self within the sustainability context of the research. Non-engineering academicians also noted that engineering academicians were unaware of how they could engage the expertise of the non-engineering academicians to carry out research. The lack of awareness was an issue similarly found in the study conducted by Valazquez et al (2005) and Martin et al (2006) and was deemed to be a hindrance in to embedding sustainable development within the university curriculum.

Another concern was the limited emphasis paid upon humanistic aspects of research in favour of research that was too engineering inclined, making these research projects less appealing to the non-engineering academicians. Engineering academicians were nevertheless very interested to work with the non-engineering academicians within a community of practice, for the purpose of teaching undergraduate modules related to sustainable development. There were also suggestions for the non-engineering academicians to be the convenors of sustainable development modules, with the engineering academicians working together with the non-engineering academicians to develop the modules.

The Engineering Team Project and Final Year Project modules were also seen as an effective platform in which the community of practice approach could be engaged, with members of the university management and students being in agreement of this approach. Students found it additionally beneficial as the community of practice would enable them to obtain views on engineering and non-engineering angles of the research. Ironically however, the students were of the opinion that the language and communication academicians would have little expertise to provide within the community of practice for these projects. Interviews with the student stakeholders further revealed that these research based learning experiences were not synchronized with the expectations of the engineering industry, based experience garnered during the internship period. While the industry placed emphasis on the broader non-engineering aspects of engineering solutions, the Engineering Team Project and Final Year Project modules were narrowly focused on technical facets.

The benefits and limitations of the community of practice approach were also revealed during the interview. Limitations include the need to ensure synergy between the engineering and non-engineering academicians, the need to sustain the interests of the participants of the community of practice, given their individual agendas, interest and aspirations and the need to make the approach relevant to the students to encourage them to participate in the community of practice without having to do it for the sole purpose of increasing their CGPAs. The failure to establish a clear set of common goals was also seen as a limitation to the community of practice initiative as it could cause academicians to impose their own views or values on sustainability onto other members of the community of practice. Nevertheless, benefits of the community of practice were also disclosed during the interviews. These include the fostering of collaboration between engineering and non-engineering academicians with the purpose of working towards research that factored in multiple dimensions, i.e. through the conception of research that focused on technical, business and societal dimensions.

Non-technical modules as a platform for sustainability competences development

It also appears that stakeholders were agreeable to the introduction of sustainable development through non-technical/non-engineering modules such as the English language and communication modules, the business and management modules and the social science and humanities modules. Stakeholders found these non-engineering modules as a suitable platform to discuss sustainability issues such as the impact of sustainable development and also public perception of sustainability. Non-engineering dimensions of sustainability were also seen as an important aspect to include in research based modules, as it was thought that such additions would enable students to understand the broader social, business and humanistic aspects related to the research they undertook.

There was also a suggestion for all management components delivered through engineering modules to be handled by academicians specializing in this area of study, namely the business and management academicians from the department of management and humanities. While there were also calls for all modules offered by this department to include sustainable development content where possible, there were also disagreements to this suggestion. Student stakeholders were concerned of this move, as the interviews revealed that undergraduate engineering students viewed non-engineering modules less seriously than they did their engineering modules. As such, making sustainable development a feature of the non-engineering modules was probably seen unfavourably by the student stakeholders interviewed, as they were aware that the undergraduate engineering students would not take the learning of sustainable development seriously if it was to be offered through the non-technical modules. These issues which are closely related to the institution's structuring of its academic departments prove to be problematic to the advancement of sustainable development initiatives within the university, as also discovered in studies conducted by Bryce et al (2004), Valazqeez et al (2005) and Mulder and Jansen (2006).

Interdisciplinarity, multidisciplinarity and transdisciplinarity through ESD

Although it advances transformative principles, interviews indicate that interdisciplinarity, multidisciplinarity and transdisciplinarity are not approaches commonly used in the undergraduate engineering curriculum of the university. This limitation was identically highlighted in the study conducted by Valazquez et al (2005) where it was found that the lack of interdisciplinary research was a factor that deterred sustainable development initiatives in higher education. The present study also found that engineering academicians did not discuss engineering fields other than the ones they were affiliated to, indicating that the engineering modules offered were discipline centric and mechanistic in nature. Discipline centrism was also found to be a factor preventing the implementation of sustainable development in engineering programmes in the study conducted by Bryce et al (2004), Valazquez et al (2006) and Mulder and Jansen (2006). Interviews conducted in the present study nevertheless suggest that a multidisciplinary approach was essential when teaching sustainable development. Collaborative teaching of undergraduate engineering modules between the engineering and non-engineering academicians was seen to be one of the means of approaching multidisciplinarity as non-engineering academicians were deemed to be those who could highlight the impact of sustainable development from a societal perspective.

The educator, ESD and challenges faced

The interviews revealed 22 desired qualities of an ESD educator, as suggested by the students, academicians, university management, industry practitioners, ESD experts and practitioners. In addition to these desired qualities, the engineering and non-engineering academician team up for the teaching of sustainable development was seen as the approach to emulate in the undergraduate engineering programme. There was nevertheless a concern that the engineering academicians would have an advantage over the non-engineering academicians as the former group of academicians were deemed by engineering students to be more convincing in bringing forth the sustainable development agenda.

It was found that academicians faced challenges in terms of teaching and developing sustainable development academic content. These challenges include the lack of time, the inability to relate modules that were too technical to sustainability, lack of understanding to relate sustainable development research to teaching, insufficient coverage of sustainable development within the undergraduate engineering curriculum which was limited to understanding, instead of application or problem solution and inadequate governmental enforcement of sustainability, which make new engineering graduates less empathetic to the sustainable development awareness they received while they were still at the university. Findings of a similar nature were seen in the study conducted by Valazquez et al (2005), Martin et al (2006) where lack of time, awareness and enforcement of policies were seen to affect the advancement of sustainable development within the higher education.

Philosophies and styles of teaching and learning

Interviews revealed various teaching philosophies and practices academicians upheld in their approach to teaching at the undergraduate engineering programme. Depending on the modules they taught, non-engineering academicians said that they try to be entertaining and interactive in class. Often, however, these efforts appear futile as students are not responsive. Nevertheless, academicians' efforts at being entertaining do seem to have been effective, as students have acknowledged that the non-engineering academicians were more fun in comparison to the engineering academicians, with the exception of the civil engineering academicians. It was also found that civil engineering academicians were also supportive of active learning strategies, specifically in project based modules. Non-project based modules however were not applicable in non-project based modules in the civil engineering programme. Interviews also revealed that the engineering programme academicians in the university had a narrow philosophy of sustainable development, as teaching of sustainability was mainly focused on natural resources. Interviews additionally found undergraduate engineering modules offered by the department of management and humanities were not developed in line with the sustainable development programme outcomes of the engineering programmes at the university.

Engineering and non-engineering academicians also seemed to be open to two-way communication during lessons, with many of them claiming to use this approach while teaching. Nevertheless, the two-way communication approach did not always result in positive outcomes, as academicians revealed that students tended not to interact when questions were posed to them. Students nevertheless revealed contradictory views. A student revealed that most engineering academicians she had encountered over her years of study at the university were one-way communicators. Academicians delivering theory based lectures were also said to favour one-way communication during their lecture sessions, indicating transmissive and mechanistic approaches at play. Students' attitudes towards learning were other issue to be to be looked into by the university when including sustainable development and ESD competences within the undergraduate curriculum. Learning problems to look out for were students' lack of ability to think critically, their lack of practical aptitude and their limited interactivity with their lecturers.

Interviews also show that academicians saw the assessment of sustainable development as a challenging task. Measures recommended by ESD practitioners to make this task less challenging was to ensure that assessments were project based, and not examination based. Sustainable development assessment categories that were suggested were components such as awareness, techniques and knowledge.

Besides assessment issues, interviews with academicians and final year undergraduate engineering students revealed that the university's philosophy towards teaching lacked sustainability. It was found that the mass lecture approach adapted by the university to accommodate large student numbers for common undergraduate engineering modules were stifling innovative teaching approaches and encouraged conventional teaching methods to be used by academicians as it was seen to be more convenient. In terms of teaching methodologies or theories, it was found that the university has not identified any specific methodology for this purpose, except for the outcome based education approach recommended by the accreditation body. Ironically though, the outcome based approach seems not to be practiced as it should, as revealed by one of the academician respondents interviewed for the present study. The lack of consciousness and understanding of transformative pedagogy amongst the academicians also seems to have resulted in them delivering educational input to students in a manner devoid of the understanding of the philosophies, theories and methodologies involved during the teaching and learning process. This lack of consciousness and understanding amongst the academicians are identical to some of the major concerns that hinder the integration of sustainable development within the curriculum, as highlighted in previous studies conducted by Bryce et al (2004), Mulder and Jansen (2006) and Sterling (2011).

In addition to the lack of pedagogical understanding to teach sustainable development, the interviews also suggest that academicians were unaware of the manner in which sustainable development was related to the modules they taught or to their areas of expertise. In the case of undergraduate engineering modules offered by the management and humanities department, it was found that the diversity of the modules offered in the department made it difficult for sustainable development to be included in all modules. If sustainable development was already included in a given module, it was also assumed to be of minimal importance, in comparison the other topics in the module. This sense of irrelevance, which also found in the study conducted by Martin et al (2006) could hinder the process of embedding sustainable development within the context of higher education.

Interviews additionally found that the department of management and humanities was not a full-fledged programme, and was therefore not subjected to the condition of having to include sustainable development as a programme or module outcome, as the engineering programmes in the university were subjected to. An ESD expert however disagreed with these views, as he explained that any academic module would have some element of sustainable development in it. These elements could be social, environmental, economic, ecological or ethical in nature. ESD practitioners suggested energy policy development and the role of corporations as possible sustainability issues that could be included.

Holistic understanding of sustainable development and sustainable engineering

In tandem with the principles and practices of a whole institution approach, interviews revealed various perspectives on the notion of a holistic sustainable development or sustainable engineering learning experience. From an academic perspective, holistic was seen as the advancement of sustainable development to undergraduate students from environmental, economic and social aspects of sustainability. From the perspective of the engineering industry, holistic was seen as the need to include human and social dimensions of sustainable development in engineering practices. The term holistic, from the perspective of the ESD practitioner, encompassed the teaching and learning, the student experience, thinking about the module and programme in whole.

Sustainable development and the university-internship-workplace dynamics

The interviews revealed that the university, the internship experience and the engineering workplace had individual roles to play in developing undergraduate engineering students' awareness of sustainable development. However, it appears that the industry saw the university as having the greatest responsibility of the three entities, as it was deemed the primary point of an engineering students' exposure to sustainable engineering. The internship experience was seen to merely enhance students' exposure to sustainable engineering as the programme was only for a short duration. As students were dispersed across various engineering industries, industry practitioners additionally revealed that it would be difficult for the internship stint to develop sustainable development competences. To counter this setback, industry practitioners suggested for the university to ensure students are placed within organizations that had an established sustainable engineering code of practice.

Universities were also encouraged to include a sustainable development component in the internship exercise and urged universities to conduct more dialogue sessions and collaborations with the industry to encourage the development of a holistic awareness of sustainable development and sustainable engineering. Interestingly though, it appears that students gained their experience of sustainable development and sustainable engineering through the internship, rather than the university, as revealed in the student interviews. Even so, the sustainability experience during the internship programme was focused upon technical perspectives to sustainable engineering, rather than the humanistic, social or communicative aspects.

Sustainable development within the higher education context in Malaysia

The interview with a member of the university management revealed limitations within the Malaysian education system that need to be addressed. One of the issues cited was the outcome based education approach within the context of secondary and higher education policies. Interviews suggest that the outcome based education approach was not practiced in secondary education, but is only introduced when engineering students enter the higher education system. It was also revealed that the adoption of a foreign education model such as the outcome based education model could be problematic for engineering education in Malaysia. An education model unique to the Malaysian education system was recommended to advance the development of a Malaysian brand of engineering education.

An ESD expert further stressed that sustainable development should be an essential feature of the Malaysian higher education context to develop a consciousness for sustainability. The university was seen as an apt platform for this purpose given its ability to act as incubator for innovation, teaching, learning and research for sustainable development. Transdisciplinarity and system thinking which are seen to be entities for the advancement of suitable development were also deemed an essential inclusion within higher education.

Sustainability and the Malaysian engineering industry

Interviews revealed that sustainable development was an integral requirement of the industry. Engineering organization with sustainability credentials are seen to have a more competitive edge in comparison to companies which did not possess these credentials. Surprisingly, industry practitioners revealed that the enforcement of sustainable development policies and practices were not fully enforced by the government, as the dealings of their company's engineers with governmental agencies revealed that sustainable development was viewed as trivial by these agencies. This is an indication that universities need to adequately train their engineering graduates to be sustainability competent to enable them to be prepared to be sustainability spokespersons for their engineering organizations.

Interviews also revealed serious gaps in the sustainable development competences the engineering industry desired their engineers to possess, and the actual level of competency possessed by their engineers. The interviews additionally suggest that the industry found recently graduated Malaysian engineering graduates to be less competent in analysing the long-term effects of sustainable engineering and sustainable development. These graduates also lacked the ability to communicate and provide ideas, had low self-awareness and knowledge of sustainability as well as an undesirable attitude towards sustainable development. This situation resulted in the industry having to re-train their engineers so they are competent to handle engineering projects and workplace responsibilities which were sustainability related. The interviews suggest that the industry was in need of engineers who were aware of energy conservation, safety and the need to retain and improve. Universities were urged to tailor their engineering programmes to meet the present needs of the industry as the industry was constantly evolving. There were also calls from the industry for universities to move away from singular perspectives of engineering to more holistic angles.

Shaping Malaysian higher ESD

Interviews with university management stakeholders indicate that the inclusion of sustainable development within undergraduate engineering programmes in Malaysia were unclear. This was due to the lack of monitoring and guidelines provided by the Engineering Accreditation Council on the manner in which sustainable development outcomes should be included as educational outcomes in undergraduate engineering programmes. Industry practitioners on the other hand were of the view that more engagement should take place between the Ministry of Higher Education and the Malaysian engineering industry to ensure Malaysian engineering education programmes developed sustainability competent engineering graduates, instead of sustainability aware graduates. Industry practitioners also commented on the need for Malaysian engineering education programmes to address the bigger sustainable development picture, namely what sustainability entails and its benefits for the individual and organization.

University management stakeholders also expressed the importance of the need to re-look the overall teaching and learning process, the present undergraduate engineering curriculum and the needs of the nation. A foreign engineering education system modelled after a western education model such as the outcome based education model was seen as unsuitable and unsustainable. There were also calls from the industry for engineering academicians to obtain professional engineering qualifications. Suggestions were also provided for the present engineering curriculum to increase its commercial value and its practical content with assistance and participation from the engineering industry. These suggestions, provided by industry and ESD practitioners, include the need for the university to decide upon the sustainable development angle it wishes to focus upon, instead of merely adding on any sustainable development component in the curriculum to adhere to the instructions of the Engineering Accreditation Council.

ESD experts and practitioners also urged universities to allow their engineering students to be able to specialize in sustainable development. Malaysian universities were also urged to actively embed real world issues faced by the community within the curriculum. There were also calls for the curriculum to provide more space for dialogue, negotiation and ownership. Higher education in Malaysia was also urged to embody sustainability not only within its curriculum, but also within pedagogical, environmental, sociological, cultural and organizational aspects of the university, in addition to viewing student voices as an essential attribute to the development of sustainable development in the university.

The interviews also revealed the importance of making sustainability as a common binding vision of the university. One manner in which this could be achieved was for the university to get all its stakeholders to jointly create notions of sustainable development. The university management, sustainability qualified academic staff and a university level sustainability champion were other suggestions provided to ensure that the university was an embodiment of sustainability and the need for it to be a common binding vision of the university.

6.11 Conclusion

This chapter highlighted the findings of Research Question 2. Key findings were compared with existing research, and interpreted in accordance with the theoretical orientation of the study. A key contribution in this chapter is the development of the guidelines to incorporate sustainable development competences holistically within undergraduate engineering programme outcomes and common module learning outcomes. Chapter 7 focuses on the discussion of Research Question 3.

CHAPTER 7
DISCUSSION OF FINDINGS

PROPOSED ELEMENTS OF THE EESD FRAMEWORK FOR UNDERGRADUATE ENGINEERING EDUCATION IN MALAYSIA

7.0 Introduction

The final research question explored stakeholders' perspectives on other additional elements that need to be looked into for the development of an EESD framework for undergraduate engineering education in Malaysia. Besides findings from literature on the various components that could make up the framework, findings of research questions one and two, along with the findings of the final research question, form the basis of the EESD framework proposed in this study.

7.1 Key interview findings on additional components for an EESD framework for Malaysian undergraduate engineering education

Interviews revealed five important issues that need to be focused upon for the development of the EESD framework. These issues are discussed in the paragraphs that follow.

Holistic approach to sustainable development by the university

This issue focused upon the manner in which a holistic sustainable development learning experience could be provided by the university. The interviews revealed respondents perspectives on the lack of holistic measures within educational and institutional practices of the university. A8 explained that the sacrifice of teaching for the acceleration of research was not an acceptable practice.

> *we must be seen to be giving as much knowledge to them so this is where teaching becomes very important of course research is is also equally important but we cannot sacrifice the teaching part you know that also ensure sustainability*
>
> (A8, lines 50-53)

A9 noted that it was important for the university to produce engineering graduates with values, rather than mere machines, while A2 argued for a holistic approach to teaching.

> *We don't want to produce only machine and engines in UTP , but full the value of human alright, from where they get that human element, from this department*
>
> (A9, lines 531-533)

IP1 explained that the engineering curriculum must highlight engineering issues from holistic perspectives through the internship exercise as well as the university experience.

> *It is necessary I think it should be looked at from a holistic ... internship is where they allowed is allowed you know allows people to see the actual working world there they make the connections and so I won't be very surprised when the students say they are not able to see the link it's a bit difficult because their exposure is limited*
>
> (IP1, lines 628-634)

U3 commented that the university was the last stop in a student's journey towards working life. As such, he stressed that educational processes in the country should be sustainable to be able to nurture the development of students in a holistic and well-rounded manner, instead of victimizing them.

> *the way I look at it you know the system itself you know the ministries we have you know, they have divided the ministry of education to ministry of higher education that itself is not sustainable you see there is no continuity …so not on the same platform on two different platforms, so then things will not work out then they blame it on everybody else*
>
> (U3, lines 139-148)

U3 additionally claimed that the university's current focus was on developing engineering students' cognitive abilities to develop thinking students. This is apparent in the following quote:

> *You see at the university the focus should be more on what they call that the cognitive side, normally because they say we are helping them we are developing them to become thinkers*
>
> (U3, lines 477-479)

Interestingly though, findings of research question 2a and 2d seem to point otherwise. This is because it was found that undergraduate engineering students of the university lacked the ability to think in a critical manner.

EP3 strongly advocated the need for a holistic perspective to sustainable development within the university's undergraduate curriculum and institutional practices, while EP1 explained that research, community and the curriculum need to work together if sustainable development was to work within a university. He also stressed that the campus should be a microcosm of a sustainable world and should practice what it preaches.

> *well usually you always say that campus community curriculum, that's three and then research, campus community, curriculum , research , those three need to work together better and the community as a learning place as a real world and authentic learning place which provides questions for research, and the campus as a microcosm of sustainable world and practising what it preaches*
>
> (EP1, lines 408-412)

Support for academicians

Respondents suggested various means of professional development to assist academicians in developing their awareness for sustainable development and become change agents for sustainability in the university. A7 was of the opinion that academicians need more opportunities to learn about sustainable development as it would help them obtain a deeper understanding of the concept, and put it into practice. Academician A5 stated that academicians need to find a focal point besides reading up on sustainability if they wanted to develop better awareness of sustainability.

> *I think on our side what we need to do is to read as much as possible because only then we can have an idea of what it is that they actually doing I mean we do know what are they doing I mean going to, tie it back to us we need to find the focal point someway to ya lah a focal point somewhere where by we need to and when we're able to only then we can actually say that we stand on our own right* (lines 92-96)

A9 said the organization of workshop or training sessions for academicians was necessary so they could align their approach of teaching sustainable development with the needs of the university. *Training, workshop because, I'm not sure whether what I understand and management want is then we can come up with what they want* (A9, lines 305-306), said A9. A7 additionally stated that academicians from the department of management and humanities need to be provided clearer research goals by the university management. This was because they had research expertise that could strengthen engineering based sustainable development research projects. She further claimed that insufficient support and exposure to sustainability made any form of support unappreciated. A10 noted that there was a need to look into the work-family balance of academicians. A10 was concerned that the current workload for academicians was too heavy.

Ironically, U3 mentioned that academicians were supposed to be sustainability qualified, and were supposed to be able to make the connections to sustainability in the modules they teach. U3 was not in support of providing academicians with additional support related to the teaching of sustainability as he felt it was unnecessary.

> ... *suppose, the most crucial part is you're a lecturer, you suppose to be qualified in sustainable development, you see can be any field you know, because the reason you're in academic is because you are suppose to be able to create that, make the connections, suppose to be able to share that so the university has no autonomy on how people do it, but make sure they do it correctly* (U3, lines 1054-1058)

U2 however was more supportive of the provision of support for academicians. He was of the opinion that it could be challenging to bring about innovation in teaching and learning as it involved a change of mindset. He thus suggested for continuous communication of sustainable development through special talks, seminars and attendance at sustainability related conferences for academicians.

> *we need to continuously communicate the importance of this element. Maybe also to conduct special talk or seminar, or even sending our staffs to conferences ...lecturers need to see outside of their discipline …or again we can bring people, expertise in that area to talk to the lecturers, to have seminar, to have special lectures for example. Then maybe they would know the relationship between what they're doing today in the sustainability development.*
>
> (U2, lines 211-233)

EP8 stated that the university had an obligation to professionally develop academicians who do not have understanding of sustainable development.

> *The alternatives professionally, I mean people need, academic need professional development…If you pretend you don't, then you're stupid…There are different ways in where we get it…You know…. If people are asked to teach things they don't understand, the institution has an obligation for them to be developed.*
>
> (EP8, lines 475- 489)

EP1 explained that academicians needed awareness to be able to make the relevant connections to sustainable development. He explained that this could be achieved through seminars, training, discussions and self-reading. EP3 suggested that the university establish links with sustainable development networks as part of its efforts in providing support for its academicians to develop their awareness for sustainability. He also noted that the individual engineering programmes and the department of management and humanities must put in conscious effort to create this awareness for its academicians.

> *First of all they each lecturer must have a clear idea on what sustainability is you know they must already read up they must …So I don't think everybody will be able to do it. One way is also they are link to some network, maybe attend some courses on sustainability some workshops, not presenting but be a participant there are quite a number and there must be some consciousness effort on the part of the department to to create the awareness for those lecturers who are interested*
>
> (EP3, lines 223-231)

Respondents A5, A6, A7, A3, A10, U4, U3 and EP5 were generally agreeable to the idea of the development of guidelines or frameworks to help academicians determine what aspects of sustainable development they could include in the modules they taught. A7 said that the guidelines should be enforced appropriately for it to be functional.

> *I think that was what I said just now, you can have beautiful guidelines and conceptual framework whatever on paper but.. putting it into practise if there's no enough support there's not enough exposure and awareness about what sustainability development is all about. you can just see it on paper*
>
> (A7, lines 172-175)

U4 explained that frameworks which were clear were necessary, especially for young lecturers.

> *Obviously, there are also lecturers not sure how to embed them.it takes a clear framework this is what you should do, what to put it in, at least a guideline kind of framework, you know, then, I believe most lecturers would like to embed that, uh, particularly those young lecturers they don't have experience, industrial experience, they don't know uh probably they don't know how to embed that* (U4, lines 89-93)

A1 and A8 however disagreed that guidelines or frameworks would be beneficial to academicians. A1 explained that guidelines were unnecessary as sustainability should be built in practice. A8 was of the opinion that guidelines would not be useful, as they were manmade. Instead, she suggested for religious principles to be introduced in undergraduate engineering modules for sustainability to be instilled in engineering students.

> *No. It will not work... guidelines all rules and regulations man made rules and regulations will not work, to me religious principles will work so it involves application of religious principles to to instil sustainability*
>
> (A8, lines 120-122)

Sustainable development opportunity provision besides formal academic input for university stakeholders

Respondents suggested many options to which sustainable development awareness could be provided in the university, besides the formal academic input through the undergraduate engineering curriculum. A9 and A2 suggested on campus activities as a means of providing sustainability exposure to undergraduate engineering students. A3 said having weekend activities in addition to the academic input as the best approach to exposing students to sustainability. A4 suggested a sustainability camp for new students during the orientation week and a national level annual event that promotes the linkage for sharing of sustainability knowledge. He also suggested that all university staff be sent for a sustainability theme team building exercise. IP3 on the other hand suggested for universities to conduct awareness weeks related to sustainability in the university, as conducted in his organization. He said, *the university itself should come out with a sustainability programme , how many universities they have sustainability programme , one week like us, one week awareness to everybody* (IP3, lines 514-516).

Development of sustainable development competences for effective practice of sustainable engineering in the workplace

This issue explored respondents responses on the competences needed to be able to become sustainable engineers within the engineering workforce. One theme, *Desired competences for effective practice of sustainable engineering at the workplace* emerged as a result of the analysis. A11 stated that it was necessary for engineering graduates to be exposed to conflict resolution as it would help them cope with the contradictions they face in their personal and professional lives.

> *so, what was I saying, so I'm looking at these contradictions, and dissecting them, and basically, my role, is what education is called, that of the facilitator, I try to facilitate students confronting with this contradictions, and to come up with solutions themselves* (A11, lines 302-304)

> *and teaching students many methods of conflict resolution, because of the contradictions that are neeed throughout their professional and personal life, and their public life if they're active citizens, what should they do, with the contradictions that they face, in order to not create enemies, basically to be friendly, and cooperative, ah engaging citizens*
> (A11, lines 342-345)

IP4 observed that the engineering graduates of present times are not taught to understand the fundamentals of sustainability and thus relied on their employers for solutions to engineering problems that had to be solved at the workplace. He held the present teaching approach practiced in higher education responsible for this setback. He was also concerned that engineering education was not preparing students to relate sustainable development to their work.

> *Yeah, yes correct because when we go out to work we don't expect to teach anymore, their suppose to have some basic, a base knowledge , you know if anything that they need to know extra they should research on it not coming to the employer and ask the employer there. employer can help, depending to the employer but most of the employers, the employees help them, this is this is the issue, correct*
> (IP4, lines 231-235)

S1 was also concerned with the present approach to teaching at the university. He commented that the university should improve on its teaching to include emphasis on the manner in which the undergraduate engineering modules students took would affect their career path. Said S1, *we students we didn't see what are the SD what are the purpose to know about these things, how are this things going to affect our future, our career, our society* (S1, lines 287-289).

Improving institutional practices for advancement of sustainable development in the university

This issue focused upon ways in which practices within the university could be improved to promote sustainable development. A11 revealed that it was necessary for the university to embrace the diversity of its academicians if the transition to sustainable development were to take place effectively. He also commented that academicians should take measures to ensure that their module content was reflective of current issues. Ironically, A3 stated that she wanted to include a sustainable development related final examination question, but was advised against doing so by the external examiner as sustainability was not a main component of her module.

U1 was of the opinion that for academicians to change, they should not only be focused on teaching, but must also network, publish their research and be cited. He explained that academicians should be more dedicated and not just teach during the stipulated contact hours. He further urged all academicians to continue to learn, besides understanding the needs of the engineering industry to be able to deliver to the students in more exciting ways. He also advised the academicians from the department of management and humanities should engage in research in integration with the engineering departments, and not in isolation.

U1 also explained that resistance to change was unavoidable. The top down approach was therefore necessary to counter resistance, he said. He further highlighted that commitment was important for change. He explained that staff needed to respect decisions made by the top management and adhere to these changes accordingly.

> *I think it's the common knowledge that people resist change but how do you approach it yeah first must come from the top, commitment must be there , must seen to be respecting to what we said and when we change you change, they must be explained properly right to the lowest level what's the benefit of doing it*
> (U1, lines 93-96)

U2 on the other hand was of the opinion that academicians were not resistant, but ignorant. He also said that academicians needed to move out of their comfort zones and be part of multidisciplinary research to understand the benefits of learning from other academicians.

> *I wouldn't say resist. Maybe ignorant is a better word. …So what we have to do is to remove these blinkers so that people can see more than their own discipline. That is the challenge that we have to do today. We'll get them out of their comfort zone, out of their discipline and to join multi-disciplinary research for example*
>
> (U2, lines 228-235)

The development of a culture of sustainable development was seen as an essential entity in developing sustainability in the university. A8 was of the opinion that the culture of the university should be nurtured and driven towards sustainability.

> *it should be a culture of higher institution especially you see not about just you know teaching kids how how to build a house, something like that, how to build a machine you know,but why, why are we building this machine, and under what circumstances it's helping human beings if it's going to create disaster , don't don't even create it, that's how I feel*
>
> (A8, lines 179-183)

Similarly, A6 also stated that the lack of awareness of sustainability among academicians was a result of the present culture in the university which did little to nurture sustainable development. A6 stated that a culture transformation was therefore necessary to counter this setback, and explained that it was not merely the role of the academicians to develop this culture, but the university community as a whole, which U1 and U3 also agreed upon. A6 explained, *you know this is something like culture, so if you want to change kan, slowly but there must be a proper planning , we have to transform our culture, all do it together* (A6, lines 437-439).

A7 however said that a sustainable development culture would be difficult to inculcate when the roles of academicians were not clearly defined and recognized by the management, while IP4 said that the creation of awareness to sustainable development in the university should not be a one off exercise, as it presently was in the university.

> *I think we are more, I think to me we are more creating awareness lah, one off one off one off things you know , after that*

> *like you said students said okay one done and then they forgot about it, there's no continuous exercise to see that we're doing this*
>
> (IP4, lines 308-310)

IP3 on the other hand explained that the culture of sustainability ought to be developed in universities as an extension of the knowledge and skills provided through the curriculum.

> *it is not only skills it also culture, we must create this culture you know, but if we don't have skills, if we don't have the knowledge then how to create a culture , …they must be careful you know they must be really careful and not treat this as a one subject where they give knowledge but then they didn't create the culture , because they must avoid that*
>
> (IP3, lines 556-561)

EP7 commented that a common vision, through the creation of awareness towards sustainable development by the management of the university was essential in pushing forth the sustainable development culture in the university.

> *you need committed people at least ..you need all the big vision and creating some kind of awareness that kind you know awareness by the people higher up to actually push through what they have set on paper but then it also needs both action at both levels it also needs that kind of you know practical steps*
>
> (EP7, lines 314-319)

Similar to A6, final year undergraduate engineering students S5 and S3 were both concerned about the lack of awareness of sustainable development in the university. S3 said that more awareness of sustainability was needed on the part of academicians. She also stated that the university should practice sustainable development and not only include it in its curriculum and research agenda. S5 commented that university programmes such as the HSE week and Green campaign only attracted a few students, and not the majority of the engineering student population. She asked for more extensive measures on sustainability awareness to be created in the university.

> *…we do have that HSE week and V5 was doing something about green village uh those kinds of events it only attract some students not all, so it does, that ideas, the sustainable idea won't extend to everyone, maybe we need something more uh, extensive.*
>
> (S5, lines 140-146)

A7 explained that the university needed to come up with sustainability policies that were realistic.

> *…if you want to put something in the policy guideline, whatever it's gonna be, be realistic enough . and if you want to put as a programme outcome even, are there enough support? are there enough facilities whatever that you know that need to be put in place? To make the practise be practised. so.. you know, I mean students can, will do it when we put things into practise for them but if we don't and we are not practising definitely they won't*
>
> (A7, lines 194-200)

IP4 was of the opinion that universities needed to decide upon the sustainability angle that it wished to focus upon, and not just generally implement sustainability in the curriculum to conform to the policy driven instructions of the Engineering Accreditation Council. IP4 was also concerned on the manner in which universities defined the term 'sustainable design' it included in its programme educational objectives. IP4 commented that the term was vague and this could result in universities having difficulties in implementing sustainability within the engineering curriculum.

> *I think the way we do it is wrong , right, we tend to think that okay this guys EAC requirement you know , then you said sustainable, so everybody got a password in the curriculum they see somewhere like sustainable design , when EAC see the word sustainable, they are happy you know, I think they don't understand what is the term sustainable design what are the components that made up the sustainable design , that's the lacking part I think we are so driven by policy we do not know how to implement it actually*
>
> (IP4, lines 449-454)

IP6 said that universities should project sustainability efforts at all times and not only through specific modules. He further added that sustainability should be integrated throughout all policies and practices of the university. He said, *so look at the university own sustainability efforts as I said but then if it's something you have to do all the time, it's not like a specific class, you know, it's integrated in the whole thing, that's, that's helpful* (IP6, lines 407-409).

A2 was of the opinion that the university management should be more transparent with how it decided upon sustainable development. A4 commented that the role of the student support services department of the university was vital in instilling the interest in sustainable development in undergraduate engineering students. A4 also stated that buy in from the management was crucial. He said that the university's middle management, heads of departments and deans must play a more active role in convincing the upper management to make decisions about sustainability.

> *First and foremost I think the buy in from the management is very crucial because although in many areas sustainability can come or can be the approach can be bottom up but in terms of university education and curriculum development has to be top down so somehow somebody in the middle rank has to play the roles or their roles to convince the top management. I'm talking about the head of department should be able to convince the dean and the dean should be able to convince the deputy vice chancellor and then the whole senate.*
>
> (A4, lines 29-35)

EP8 claimed that the vice chancellor had an important role to play in making the university more sustainable. He was also of the opinion that a top down approach focused on advocating a vision and coherent account of what sustainability entailed was important.

> *I think you want a top down approach which encourages the things that are amongst student or individual faculty. Because I think you need some kind of a vision and the coherent account of what it might be about, otherwise it's just confusion about what we're talking about.*
>
> (EP8, lines 589-592)

It was found that the middle management had a substantial role to play in advocating the university's sustainable development agenda. A4 for instance exclaimed that the change of heads of departments and clubs related to sustainable development could affect sustainability. He said that this setback should be looked into seriously as it could diminish student's passion for sustainability. A4 commented, *we do have Earth Club or something, but after the president left, so nobody there's nobody who took over the thing* (A4, lines 627-629). A6 explained that it was the role of the head of department to aid the academicians under his supervision with sustainable development issues related to research and teaching as he felt that the *immediate boss, knows better* (A6, line 164). A6 also commented that the present mechanism used by the university to assess academicians' annual performance needs to be fine-tuned.

It was also found that the lack of planning, implementation and monitoring had an impact on nurturing sustainable development in the university. A1 for example said due to the lack of enforcement, his own research endeavours were not affected by the university's sustainable research agenda. *Well the university emphasizes on the sustainability issues and green aspect, but there is no enforcement that you need to do this, this, this, this, so obviously it doesn't affect my research much, or my activities* (A1, lines 154-156), said A1.

Alike A1, A8 and A4 were also concerned about the enforcement of sustainability in the university. This was apparent as they both stated that there was a lack of this presently in the university. U1explained that there was a greater need to emphasise implementation and monitoring processes while U3 said more facilities should be put in place to develop sustainability consciousness among the campus community.

IP4 explained the importance for universities to address short-term and mid-term plans. He also noted the importance of making sustainability initiatives a continuous exercise to ensure it is worked on appropriately. EP3 on the other hand explained that the university campus does not provide the environment for thinking in terms of sustainability and there was presently a disconnected notion of sustainability in the campus. He said that measures should be taken by the university to ensure that the campus community is made to adhere to sustainable philosophies and technologies.

> *we in the campus and community outside the campus must be made to consume sustainable philosophies and technologies so when when you do that, we we create a consciousness not only an awareness a consciousness significance the the meaning of sustainability so that's what I was thinking what the university can do and what does not have yet perhaps*
>
> (EP3, lines 75-79)

EP4 stressed the need for proper planning if sustainable development was to be effectively implemented as it would have an impact on the staff and students. *Based on the implications, I would say of planning it properly. Like you said, it affects staffs, it affects students eventually because the lecturers are not able to deliver as how they should be delivering it* (EP4, lines 442-444), said EP4.

Respondents also commented on issues that presently stifled the promotion of sustainable development in the university. Among these issues were the academicians who worked in silo (A6), unrealistic KPIs (A9), unsupportive working environment (A9) and lack of teaching manpower (A9). A4 was of the opinion that the university's departmental system for undergraduate engineering programmes stifled the promotion of sustainability. Besides these issues, pre-fabricated research, put forth through the university's research groups were also seen as an impediment to the academicians' creativity, said A11.

For EP1, it was necessary for academicians to work on research projects that have sustainable development issues and real community issues. He was of the notion that it was the research that had to determine the type of expertise needed, and not vice versa.

> *I think that's the key bringing in , starting with this issues , can determine what kind of engineers can be used for this issue, oww we use chemical engineers for that and how do we manage this projects normally comes from management, how do we communicate it's the major..so how he thinks about you know, so quite, the expertise and not the other way round where the expertise needs to determine what are the things to be researched and discussed , so it's not about engineering it's about what do you need to resolve this issue of communicating , manage it.*
>
> (EP1, lines 196-202)

Additionally, EP3 was concerned that there was a lack of understanding and respect of the academicians' decades of experience. This, he felt, hindered the advancement of sustainability in the university.

U3 explained that resistance to sustainable development in the university was a result of prejudice, which has been caused by ignorance. It was also a form of mechanism to preserve an academician's territory, said U3. U1 on the other hand was of the opinion that such resistance was unavoidable, and the top down approach was the best means to counter resistance. Said U1, *I think it's the common knowledge that people resist change, but how do you approach it yeah first must come from the top, commitment must be there , must seen to be respecting to what we said and when we change you change* (U1, lines 93-95).

EP7 noted the importance of a commitment to push the sustainable development agenda through. She also suggested the development of a movement within the university to advocate the awareness of sustainability as a means of tackling resistance to it.

Interviews revealed interesting perspectives on sustainable development and the undergraduate learner. A9 said that the lack of sustainable development consciousness among undergraduate learners were a result of their ignorance and attitude of not being bothered.

> *Maybe true, okay because of, first we ask the students what they understand about sustainability development , maybe there are initiatives there are information about that maybe they don't know, they in the state of ignorance, sometimes our students they only doing what they want to do, they work , after that they enjoy enjoy, sometimes they don't know what happen surrounding them*
>
> (A9, lines 497-501)

A3 however said that students could be of the opinion that sustainable development lacked emphasis in the undergraduate engineering curriculum as it was not obviously emphasised by the academicians. This lack of emphasis could be the reason for why students thought sustainability was not being discussed in the modules. EP5 stated that sustainable development was not a high priority on students' agenda. These findings are nevertheless contradictory to the perspectives of undergraduate engineering students, as most of the respondents claimed to be eager to want further about sustainable development and sustainable engineering. S3 explained that as sustainable development was niche, students who do not have an interest in it would not bother to read up about it on their own, because it was not being taught to them. This, said S3, was the case in the university presently. She also stated that the green consciousness of the engineering students in the university was much lower in comparison to those from other Malaysian universities, as a result. *…Sustainability is something….niche I would say, and students, they don't have, they're not exposed to, and if they don't have the interest, they won't read on their own, because it's not thought* (S3, lines 480-496), said S3.

The communication of sustainability featured as an essential finding of the present study. This indicates that communication was seen as an important catalyst in developing the university's sustainable development agenda, and it was presently severely lacking prominence in the university's sustainability journey. U1 agreed that communication was an essential aspect of sustainable development efforts within the university. He said it was important for changes to be communicated and explained in the proper manner, to all levels of the university community through engagement and communication sessions. He commented that the recent university wide survey showed that there was a lack of communication of university initiatives to the university community and this was a major problem.

> *see whether it helps or not I don't know, I hope lah , I get worried too if it's not so good, you know...if the thing is not so good, we solve the problem, the communication, they don't know, what we are doing , and not given proper attention or proper guide or proper scope , I don't know*
>
> (U1, lines 129-132)

The findings of this university wide survey were also reflected in the responses of the interviewees of the present study. A7 was of the opinion that there was an urgent need to understand what sustainability entailed from a non-engineering point of view, and this understanding should be communicated to the academicians of the management and humanities department. She also acknowledged that there was presently a lack of communication on sustainability in the university. Similarly, A3 said that she was unaware of sustainability initiatives in the university as it was not well communicated to the campus community.

> *They should make it compulsory, not compulsory, they should tell this, there is such activity, inform this activity around the campus so, everybody will know. If you're just keeping it within your village itself, it's too small the community, so you should enlarge.*
>
> (A3, lines 536-538)

It was also ironic to find that A9 was unaware that sustainable development featured as programme outcomes in the undergraduate engineering programme curriculum, indicating a lack of communication of the university's inclusion of sustainability within the undergraduate curriculum to the academicians.

A4 and EP3 were concerned that there was a lack of promotion of sustainability initiatives across the university, while U4 stated that academicians from his department have never come to him to discuss the inclusion of sustainability within the modules they taught.

> *I think coming here to see me about talking about sustainability in their courses I don't think I mean no one has done that la. But I think they are aware, they are aware of such things and they are aware uh, but how do they embed and how do they teach students and up to what level I'm not too sure, but because it is it is a trend that is the whole world is talking about it.*
>
> (U4, lines 66-70)

EP1 explained that since sustainability was trans-boundary in nature, it was important for academicians working on engineering related sustainable development research to be able to communicate about their research. This is where the non-engineering aspects would be essential, said EP1.

> *Oww okay* [the social science people, management people] *yeah I think all in this sustainability are trans-boundary I think it's very important people working on an engineering sustainability in the issue that they able to communicate to others about this issues , they can make accessible to lay people that a lot of the non-engineering skills or competencies can be very relevant if you do like a community based project like I was talking about it* (EP1, lines 186-190)

EP8 explained the necessity for clear articulation of what sustainability is to academicians. This should then lead to the organization of activities within the university to enable academicians to identify with and prepare students for the challenges that they may encounter in including sustainability within the curriculum. *So I think at least some clear articulation on what we mean by it and giving some, leading some activities to the university which people can identify with, relatively tangible, about recycling or opening up the campus to other people to use it* (EP8, lines 600-602), said EP8.

EP4 commented that it was important to define the limits, objectives and aims of sustainable development due to the multiple ways in which it is defined. This should then be communicated clearly to all stakeholders.

> *…And I think the less you have an idea and tie this concept down, you're always going to be floating around…So, yes it becomes very important if you can define limits and the aims and objective. What sustainable means in any particular subject.*
>
> (EP4, lines 77-85)

S1 observed that there was a lack of communication between university management, academicians and engineering students. He said that this limitation should be addressed so that the teaching of sustainable development could be improved upon in the undergraduate engineering programme.

> *Okay I think the key issue, the most important thing, is the communication between the management the lecturer and students itself. Because we students we didn't see what are the SD what are the purpose to know about these things, how are this things going to affect our future, our career, our society*
>
> (S1, lines 286-289)

7.2 Discussion of key findings of stakeholders, ESD experts and ESD practitioners on the dimensions of a Malaysian EESD framework

The findings of Research Question 3 revealed additional concerns to be looked into to address the current problems faced by the university and its academicians in integrating sustainable development outcomes within programme and module learning outcomes of the undergraduate engineering programme. These concerns provide additional insight for the development of the EESD framework. The findings of the interviews are summarized in the paragraphs that follow.

Holistic approach to sustainable development

In tandem with the principles of a whole institution approach, academicians, university management and industry practitioners revealed various interpretations of the manner in which a holistic approach to sustainable development should be approached by the university. Academicians saw a holistic approach to sustainable development as one that gives equal emphasis to teaching and research. Prominence of research over teaching was seen to be unacceptable. Academicians also argued for the need to develop values amongst students, if holistic engineering graduates were to be developed. Industry practitioners on the other hand stressed the importance of the internship and university experience in building undergraduate engineering student’s holistic understanding of sustainable development. Members of the university management however felt that sustainable educational processes played an immense role in nurturing the development of holistic students. Also stressed upon was the need for the university to focus upon the development of students’ cognitive abilities. ESD experts and practitioners also advocated the need to develop holistic sustainable development perspectives using collaborative means within a university’s research, curriculum and community. Also highlighted was the need to project the university campus as a practicing microcosm of a sustainable world.

Support for academicians

Interviews indicated professional development as an essential support mechanism for engineering programme academicians as it would enable them to develop their awareness for sustainable development and become the university’s change agents for sustainability. Academicians saw professional development as an avenue for them to gain a deeper understanding of the concept of sustainable development, and to be able to put it into practice. Specifically designed workshop or seminars to address the manner in which academicians should align their approach to teaching sustainable development with the needs of the university were suggested for this purpose.

Interviews also revealed that non-engineering academicians from seek clearer research goals from the university to enable them to contribute their expertise towards sustainable development research projects. The heavy workload of the academicians was also seen as a concern that needs to be addressed. Professional development of academicians was a similar issue highlighted in the study conducted by Valazquez et al (2005) and Leal Filho (2009), where it was found that a lack of professional development and staff training deterred the progress of sustainable development in the context of a higher education institution.

University management respondents however were of dissimilar views. One of the respondents was agreeable. The other felt that professional development for academicians was unnecessary, as academicians were expected to already be qualified to relate sustainable development to the modules they teach. ESD practitioners however, stressed that it was the university's obligation to professionally develop their engineering programme academicians who did not have adequate understanding of sustainable development and ESD. Seminars, trainings, discussions, conferences, self-reading and the establishment of linkages with sustainable development networks were suggested as ways in which professional development could be provided for academicians. The creation of awareness of sustainable development for its faculty members by the individual engineering programmes and the department of management and humanities was also urged.

Guidelines or frameworks for the teaching of sustainable development

Interviews revealed that most stakeholders were in favour of guidelines and frameworks to assist academicians determine aspects of sustainable development they could include in the modules they taught. A university management stakeholder deemed such frameworks as important for academicians, specifically for young lecturers who were less experienced. A non-engineering academician who was also in support of these teaching guidelines highlighted the necessity for it to be enforced appropriately for it to be functional. There were nevertheless academicians who opposed the idea of providing academicians with guidelines or frameworks for the teaching of sustainable development. An engineering academician respondent for instance viewed such guidelines as unnecessary as he was of the opinion that sustainability should be an intrinsic value and practice.

Sustainable development from a non-academic angle

Academicians and industry practitioners recommended several options through which non-academic sustainable development awareness could be provided in the university, besides the curriculum. Industry practitioners suggested for sustainability awareness programmes to be organized at the university. Academicians recommended conducting weekend activities, sustainability camps during student orientation sessions and national level sustainability events that promote linkage for sharing of knowledge on sustainable development for students. As for the staff, the university was encouraged to conduct sustainability themed team building activities for newly recruited staff.

Effective practice of sustainable development at the workplace

Interviews with industry practitioners show that the engineering graduates are not familiar with the fundamentals of sustainability. This makes them a liability, as they are heavily reliant on their employers to come up with the intended solutions to sustainable engineering problems that need to be resolved at the workplace. Mechanistic teaching approaches presently practiced at universities were felt to be a possible cause for engineering graduates lack of sustainable development fundamentals. The industry was additionally concerned that engineering education in Malaysia was not preparing students to relate sustainable development to their work. This is most certainly a cause for concern, as it points to a mismatch between the university's preparation of its engineering students, and the sustainable engineering competence expectations of the industry. A similar concern was raised by a student stakeholder, who was of the notion that the university should look into its philosophy of teaching, given the limited emphasis placed on relating the undergraduate engineering curriculum to the needs of the engineering industry, and the career path of an engineer.

Improving institutional practices for advancement of sustainable development in the university

Findings indicate several issues that need to be addressed in order to improve the institutional practices of the university to advance the sustainability agenda within the institution. Interviews suggest that academicians have an important responsibility to play in embracing and advancing sustainable development at the university. Interviews however also suggest that academicians seem to face challenges in carrying out these responsibilities. In terms of the development of educational content, interviews show that academicians faced problems in ensuring that the modules they taught reflected current issues. There also appears to be discrepancies in terms of assessment. While academicians were willing to include sustainability focused examination questions, external examiners do not seem to view sustainable development as a significant component to be tested in undergraduate final examinations. Similar to the study, syllabus constrain was also cited as a challenge towards making sustainable development mainstream in a study conducted by Down (2006).

It was also found that change and commitment was strongly urged of all academicians. Similar findings were revealed in the study conducted by Martin et al (2006), where the lack of commitment was seen to be a hindrance to the advancement of the university's sustainable development agenda. Besides this, interviews with university management stakeholders indicate that academicians not only needed to be focused on teaching, but also on networking, publishing research and being cited. It is interesting to note that these issues, labelled as the 'race for scientific credentials' were deemed as setbacks in advancing sustainable development initiatives within engineering education in Mulder and Jansen's (2006) study.

There were also calls for academicians to understand the needs of the engineering industry, to be engaged in research, in integration with academicians from the engineering departments of the university, and to not only work on research related to their specific area of expertise or in silo. These findings bear resemblance to the findings of the studies conducted by Bryce et al (2004), Valazquez et al (2005) and Mulder and Jansen (2006).

Interviews also show that the university management felt that academicians found it difficult to move out of their comfort zones, and were not comfortable working on multidisciplinary research. From a whole systems perspective, however, top-down approaches are believed to advance transmissive and mechanistic policy making practices. Interviews however revealed that the university management found the top-down approach to be the most appropriate measure to introduce changes within the university. The benefits of the top-down approach in disseminating the importance of sustainable development within the curriculum were also highlighted by ESD practitioners, they nevertheless cautioned that the top-down approach should be seen as one which advocated a vision and was coherent. This was essential to evade confusion of what sustainability entailed. As discovered in the present study, the significant role played by the university management in advancing sustainable development in the context of the university was also found in studies conducted by Valazquez et al (2005), Martin et al (2006), Brinkhurst et al (2011) and Scott et al (2012).

Interviews additionally suggest that the university could do more to recognize the roles of academicians and provide them adequate support in embracing change towards the advancement of sustainable development. This in turn is deemed to have an impact on the success of sustainability in the university. The lack of institutional support bears resemblance to the findings of the study conducted by Valazquez et al (2005) and Scott et al (2012), where it was found that the lack of it was a hurdle in integrating sustainable development within the organization.

It also appears that academicians were of the notion that their diversity as engineering and non-engineering academicians of the institution was not very appreciated. This was seen as a factor that could jeopardize the university's sustainability initiatives. Similar findings were revealed in Mulder and Jansen's (2006) study, where threat to academic freedom and preservation of discipline centric borders was believed to be a setback in carrying out sustainable development initiatives within engineering education programmes. These findings are a contradiction to the whole institution perspective to sustainable development. As a counter measure, the university could look into its curriculum, pedagogy and policy to forward the whole institution approach within its practices.

Interviews also suggest that the culture of the university was an essential factor to drive sustainability across the university. Interviews show that the present culture in the university could be improved to emphasise the need for sustainability. Students were similarly concerned about the lack of awareness of sustainable development in the university, especially among the academicians. Consistent with whole systems principles, undergraduate engineering students also revealed that it was imperative for the university to practice sustainability and not merely focus on it in the curriculum and research. A transformation of culture is therefore seen to be a possible solution for this setback, with the university community playing their respective roles to ensure the culture of sustainability is nurtured in the university.

Academicians, industry practitioners, ESD practitioners and students also provided suggestions on the manner in which the culture of sustainability could be nurtured in the university. These recommendations include (a) the need for the university management to recognize and clearly define the roles of the academicians, (b) not make the creation of sustainable development awareness a one-off exercise as it is being currently practiced in the university, (c) develop a culture of sustainability as an extension of the knowledge and skills provided through the curriculum, and (d) make sustainable development a common vision of the university.

Policy vs. practice

Interviews show that the university has to come up with sustainable development policies that are more practical. This is to ensure these policies are put into practice in accordance with the transformative and whole institution paradigm. This is in addition to providing the necessary support and facilities to ensure the policies are enforced appropriately. Academicians cited the case of the university's recent inclusion of sustainable development within programme outcomes as an example of these practices. The lack of policies to promote sustainable development within the university was also found to be a factor that deterred the advancement of sustainable development in a university, as similarly revealed in the study by Valazquez et al (2005), Moore (2005) and Down (2006).

Industry practitioners advised universities to decide on a specific sustainable development angle it wished to focus upon, instead of inserting any element of sustainable development in the undergraduate curriculum to conform to the instructions of the Engineering Accreditation Council. Industry practitioners also cautioned universities to be unambiguous in defining sustainable development within the curriculum. This was to avoid difficulties in implementing sustainability within the curriculum. Congruent with views of the academicians, industry practitioners also commented that it was essential for the university to integrate and project sustainability within all its policies and practices at all times.

Managing sustainable development

In tandem with transformative practices, academicians revealed the need for the university's transparency on its decision to make sustainable development a component within the curriculum. Academicians noted that buy-in from the university management was essential for the institution's sustainable development agenda. Additionally, middle management, consisting heads of departments and deans were also urged to play a more active role in convincing the upper management to make transparent, decisions involving sustainability within the university's curriculum. Heads of department were also viewed as accountable for the professional development of academicians under their supervision, specifically in relation to sustainable development related research and teaching.

Planning, implementation and monitoring for enforcement of sustainable development

Interviews with members of the university management suggest that there is presently a lack of planning, implementation and monitoring of the university's academic and research initiatives that are related to sustainable development. Academicians also pointed out that enforcement of these initiatives are lax, while facilities to develop sustainability consciousness amongst the campus community were inadequate. It was also found that the campus did not provide the atmosphere for sustainability to thrive. Besides this, it also appears that there is a disconnected notion of sustainable development in the institution.

Industry practitioners also stressed the need for universities to address short and medium term plans, in addition to making sustainability initiatives a continuous effort. ESD practitioners meanwhile commented on the need for proper planning if the university is to effectively implement sustainable development to project a positive impact on the staff and students. These findings are pointers for University X to take heed of, as it is an indication of unsustainable whole institution practices to the inclusion and advancement of sustainable development at the university.

Issues stifling the advancement of sustainable development

Interviews with academicians revealed various issues that were presently stifling the advancement of sustainable development at the university. These issues include academicians who work in silo, impractical KPIs, unsupportive working environment, the lack of teaching manpower, the university's departmental system, pre-fabricated research that stifled creativity, and the lack of understanding and value for academicians experience and expertise. Similar findings were found in studies carried out by Bryce at el (2004), Valazquez et al (2005) and Mulder and Jansen (2006). Prejudice ignited by a sense of ignorance is also seen to be a factor of resistance to sustainable development. Findings show that such resistance is a result of academicians trying to preserve their expertise, or to justify that their area of expertise was far more important than the expertise of other academicians.

As evident through the interviews, commitment is an essential measure for the advancement of sustainable development at the university. The top down approach is seen as a means to tackle resistance to sustainability. Besides commitment and the top down approach, the establishment of a movement within the university to advocate awareness of sustainable development was also suggested by ESD practitioners. The university was also urged to encourage its academicians to work on research projects that focused on sustainable development and real community issues so academicians were obligated to be conscious about sustainability. Additionally revealed was the necessity to ensure that it was the research project that determined the type of expertise needed to carry out the study, instead of vice versa. This is seen to benefit academicians and the university as a whole, as it projects sustainable and transformative practices which are favourable to the university in the long run.

Undergraduate learners and sustainable development

Academicians and ESD practitioners were of the view that sustainable development was not a priority for undergraduate students. Although the student survey found that undergraduate engineering students of the university viewed sustainable development as an important inclusion within undergraduate engineering modules, interviews however suggest that the green consciousness of the engineering students was much lower in comparison to students from other Malaysian universities. It appears that students' lack of sustainable development consciousness is attributed to their ignorance and attitude of not being bothered.

Academicians nevertheless admitted that their ambiguous or vague discussion of sustainable development through the undergraduate engineering modules could possibly be a cause for the students to think that sustainable development was not prominently addressed in the undergraduate engineering curriculum. Interestingly also, students admit that they do not bother to read up on sustainable development because it is not being taught to them. As sustainable development is a niche area of study, student interviews show that only those interested would put in the effort to be concerned about it.

Communicating sustainability to university stakeholders

Communication was found to be an essential medium to develop the university's sustainability agenda. Interviews with students, academicians and university management reveal that there is presently a lack of communication on sustainability in the university. Communication practices were also found to be unsustainable. These findings are similar to the findings of the study conducted by Valazquez et al (2005), where it was revealed that the lack of opportune communication and information could deter sustainable development initiatives within a higher education institution.

Interviews also show various communication setbacks in the university which have led to complications in promoting sustainable development at the university. University management stakeholders acknowledged that communication is a vital aspect of the university's sustainability goals. Interviews however show that the university has not been sufficiently engaging, communicating and explaining the sustainability initiatives taking place in the university to all levels of the university community. Similar concerns were raised during a university wide survey conducted by the university.

The interviews also found that sustainability related changes in the undergraduate curriculum were not thoroughly explained to academicians and students. This resulted in academicians and students being unaware of the inclusion of sustainable development as a programme outcome of the undergraduate engineering programmes offered by the institution. Interviews with students show that the lack of communication between students, academicians and members of the university management was a setback that required urgent attention to improve upon the teaching of sustainable development in the undergraduate engineering programme.

The lack of promotion of sustainable development initiatives across the university was another communication related concern raised by academician and student stakeholders. Interviews additionally revealed that academicians urgently needed to understand what sustainability entailed from non-engineering perspectives.

Communication is viewed as an essential tool to promote sustainable development by ESD experts and practitioners. Given the trans-boundary nature of sustainable development, communication and clear articulation of sustainability enable academician stakeholders of the university to identify with and prepare themselves for the challenges they may encounter in including sustainable development within the curriculum. Due to the multiple ways in which sustainability is defined, ESD practitioners revealed the need to define and clearly articulate the limits, objectives and aims of sustainable development to all stakeholders of the university. These findings bear similarities to the study carried out by Valazquez et al (2005), where the lack of standard definitions and concepts related to sustainability was found to be a factor that deterred the advancement of sustainable development initiatives within the university.

7.3 The proposed Whole Institution EESD framework

The university's transition to the transformative realm is essential if it views its inclusion of sustainable development within the curriculum seriously. As found in the frameworks and models reviewed in Chapter 2, and as proven by the findings of this study, for EESD to be successfully incorporated in the institution, the university cannot be satisfied with only including sustainable development within its programme outcomes and module learning outcomes. Section 7.3 thus discusses this concern, through the second original contribution of this study, the whole institution EESD framework for engineering education in Malaysia.

The key findings from this study suggest that nine interlinking dimensions must be focused upon for EESD to be effectively instituted within the undergraduate engineering programme. The nine dimensions that advance a whole institution approach to EESD are a university's (a) core values, (b) academic philosophies, (c) organizational culture, (d) curriculum and assessment, (e) academic and institutional policies, (f) academic and institutional operations, (g) research, (h) pedagogical philosophies, and its (i) relations with its stakeholders. The findings of this study provide vital information of the key dimensions that should be considered by the university, in transiting from its present accommodative, transmissive and mechanistic ways, into the transformative paradigm. The whole institution EESD framework is illustrated in Figure 7.1.

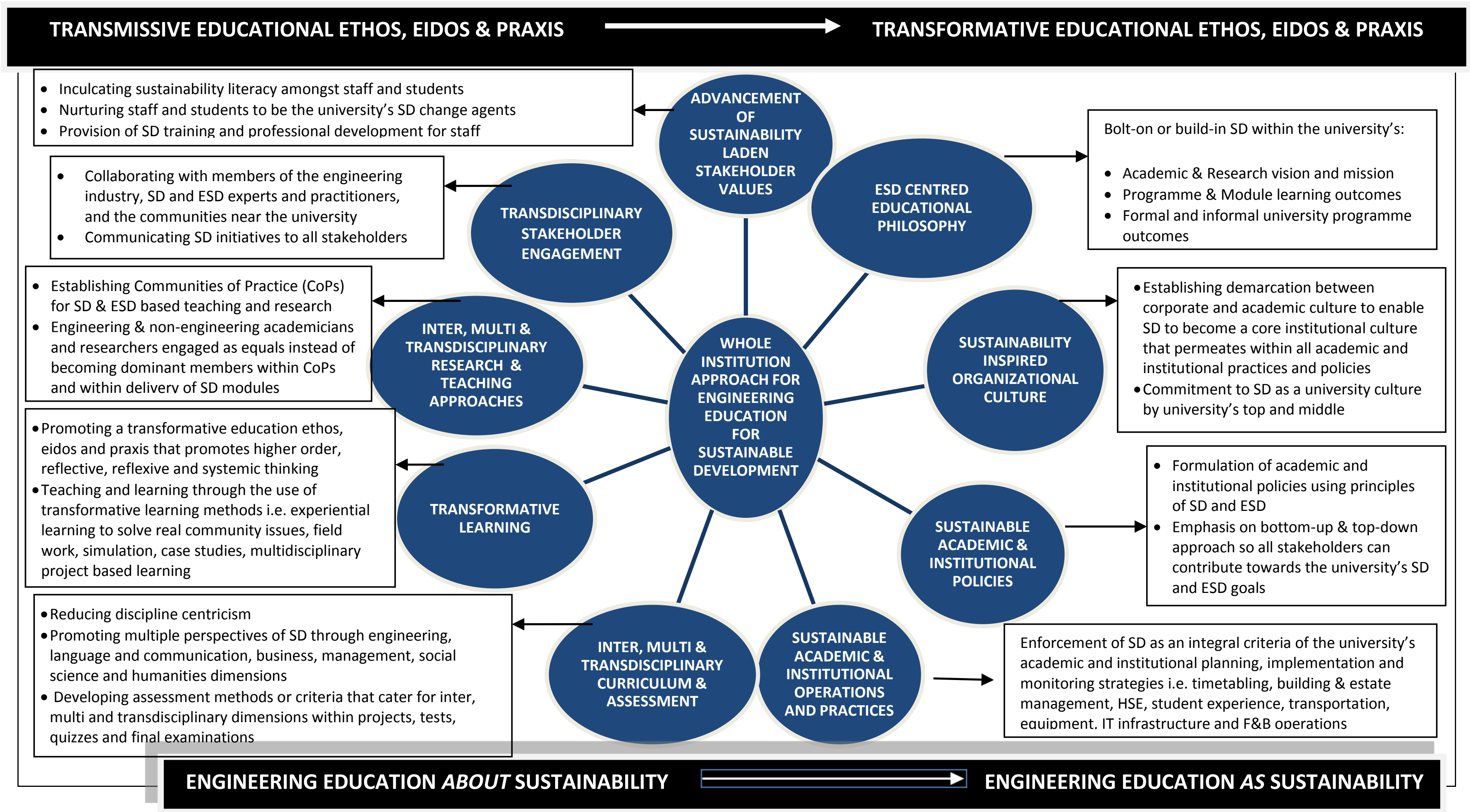


Figure 7.1: Whole Institution EESD Framework

As presented in Figure 7.1, sustainability must permeate through the institution as a whole, and must not be selectively focused upon a particular scope. When EESD is advanced through an approach that operates within transformative, whole systems and ESD philosophies, the university will be able to transit from its transmissive educational ethos, eidos and praxis to a transformative ethos, eidos and praxis realm. It is therefore beneficial for the university to institutionalize all nine dimensions of the whole institution EESD framework, to enable it to shift from engineering education *about* sustainability to engineering education *as* sustainability, i.e. the transition from the accommodation stage to the transformation stage.

The whole institution EESD framework is impactful at several levels, namely at the institutional level, at the Engineering Accreditation Council level and for the Mnistry of Education level. Universities wanting to infuse SD or ESD within their undergraduate programmes, or make SD an integral university culture or vision, could, for instance, adapt or adopt this framework within their existing institutional set up. The framework can also be used by universities as a check and balance mechanism, as it would enable these institutions to make guided decisions on curricula, pedagogical, organizational and policy matters associated with the incorporation of SD and ESD within the institution.

The framework will also be advantageous for the Engineering Accreditation Council. As the present accreditation manual does not describe in detail the manner in which sustainable development could be pedagogically infused within undergraduate engineering programmes, the framework could therefore be utilised by the Council to develop accreditation guidelines that advance holistic SD teaching and learning experiences for academicians and students. Additionally, the nine dimensions highlighted in the framework can also be used by the Council as a measure to develop whole institution centered accreditation practices, or as a tool to assess the extent to which SD has been incorporated within the university.

At the level of the Ministry of Education, specifically the Department of Higher Education, the framework can be used as an aid to formulate SD or ESD centric nationwide higher education policies and guidelines for the use of public and private institutions of higher learning. The Ministry could also use the framework as a pointer to develop professional development programmes or postgraduate certification in higher education for lecturers wanting to specialize in the teaching of SD and ESD.

7.4 Conclusion

This chapter discussed the key findings of Research Questions 3. The second key contribution of the study, i.e. the whole institution EESD framework was also highlighted and discussed. The chapter that follows concludes the study.

CHAPTER 8

CONCLUSION

8.0 Introduction

This is the final chapter of this thesis. Highlights of the chapter include the novel contributions of the study and its implications for EESD in Malaysia, the limitations of the study and recommendations for future research.

8.1 Original contribution of study

This study focused on exploring stakeholders' perspectives on the incorporation of EESD within undergraduate engineering programmes. As established in Chapter 2, there is presently a lack of research carried out to explore engineering education stakeholders' views on the incorporation of sustainability within the Malaysian undergraduate engineering education context. There is also limited research on holistic guidelines or whole institution frameworks for the incorporation or assessment of EESD within the Malaysian undergraduate setting. Research on the incorporation of EESD using inter, multi and transdisciplinary transformative contexts is also limited. Most research cited in Chapter 2 lacked diverse stakeholder perspectives. The multiple perspectives and data collection strategies obtained from higher education stakeholders, ESD experts and practitioners also added to the novelty of the methodology of the study.

This study puts forth two novel contributions for undergraduate EESD in Malaysia, which, to my best knowledge, has not been explored through holistic and whole institution dimensions. The first original contribution of this study is the guidelines for the holistic incorporation of sustainable development competences within undergraduate engineering programmes, as seen in Table 6.1.

Table 6.1: Guidelines to incorporate sustainable development competences holistically within undergraduate engineering programme outcomes and common module learning outcomes

Category guideline	Competences
Undergraduate Engineering Programme Outcomes	
Category guideline	**Competences**
1 Competences for comprehension, expression and demonstration of sustainable development consciousness	1, 2, 4,5, 19, 20 and 21
2 Competences for community based problem resolution	13, 14 and 15
3 Competences for holistic problem solving	9 and 10
Common Undergraduate Engineering Modules	
Category guideline	**Competences**
1 Competences for appreciation of the need for sustainability consciousness within engineering practices affecting society	22, 24, 25, 26, 27 and 29
2 Competences for the observation of sustainable development at individual and social levels	6, 13, 14, 15 and 18
3 Competences for comprehension, expression and demonstration of sustainable development consciousness	1,2,3,4,5 and 7
4 Competences for holistic approach to problem resolution	9 and 10
Common Undergraduate English Language & Communication Modules	
Category guideline	**Competences**
1 Competences for the comprehension of sustainable development	1,2,3,4,5,7,8,9,10 and 12
2 Competences for the expression and demonstration of sustainable development consciousness	20, 21,22, 25,26,27,28,29 and 30
3 Competences for implementation of sustainable development conventions within the community at individual, societal and professional levels	13, 17 and 18
Common Undergraduate Business and Management Modules	
Category guideline	**Competences**
1 Competences for the expression and demonstration of sustainable development consciousness	20,21,22,26,27,28,29 and 30
2 Competences for the comprehension of sustainable Development	1,2,3,4 and 5
Common Undergraduate Social Science & Humanities Modules	

Category guideline	Competences
1 Competences for the comprehension of sustainable development	1,2,3,4,5,6,7,and 8
2 Competences for the expression and demonstration of sustainable development consciousness	26,27,28, 29 and 30
University Programmes	
Category guideline	**Competences**
1 Competences for the expression and demonstration of sustainable development consciousness at individual, professional and societal levels	18,22,23, 25,26,27,28,29 and 30
2 Competences for local and global comprehension of sustainable development using empirical and non-empirical measures	1,2,3,4,5,6,7 and 8
3 Competences for holistic problem resolution	9,19,11,12 and 13

These guidelines are the result of the analysis of the following 30 sustainability competences, rigorously validated and tested via principle component analysis, expert appraisals and higher education stakeholder reviews.

1. Understand people's relationship to nature
2. Hold appropriate understanding of how the economy, society and environment affect each other
3. Hold personal understanding of the environment which is derived from direct experience
4. Local to global understanding of how people continuously impact on the environment
5. Understand how science and technology has changed nature and people's effect to the environment
6. Understand how cultural and social values influence how resources are viewed
7. Analyse a sustainability issue creatively, critically and systemically using scientific, social science and humanities approaches
8. Able to consider present and future directions of society and environment, and personal role and contribution to the future
9. Think of a holistic approach to solving an engineering problem
10. Think of a holistic approach to solving real life complex problems
11. Able to participate in groups consisting individuals from many fields or disciplines of study to jointly evaluate causes, put forward and work out problems, and provide solutions to problems
12. Apply engineering skills to solve real life sustainability problems facing society
13. Apply language and communication skills to solve real life sustainability problems facing society

14. Apply business and management skills to solve real life sustainability problems facing society
15. Apply social science and humanities concerns to solve real life sustainability problems facing society
16. Able to critically reflect on own assumptions and assumptions of others
17. Able to critically reflect on issues on a personal and professional level
18. Able to manage and direct change at individual and social levels
19. Able to express personal responses to environmental and social issues
20. Ability to demonstrate and articulate sustainability related values such as care, respect, charity, social and economic justice, commitment, cooperation, compassion, self-determination, self-reliance, self-restraint, empathy, emotional intelligence, ethics and assertiveness
21. Play the role of responsible citizens at the local and global level for a sustainable future
22. Develop appreciation of the importance of environmental, social, political and economic contexts of engineering processes for sustainability
23. Consider implications of engineering processes in relation to the environment
24. Consider implications of engineering processes in relation to the society
25. Consider environmental issues in relation to the society
26. Appreciation of all living entities
27. Appreciation that current actions can impact on the quality of life of future generations
28. Respect and value cultural, social and economic and biodiversity
29. Appreciation of the variety of approaches to sustainability issues
30. Appreciation for the need for lifelong learning in relation to sustainability issues and change

The second original contribution of this study is the whole institution EESD framework (Figure 7.1). This framework comprises nine interlinking EESD dimensions which Malaysian universities could use to advance transformative EESD within their institutions.

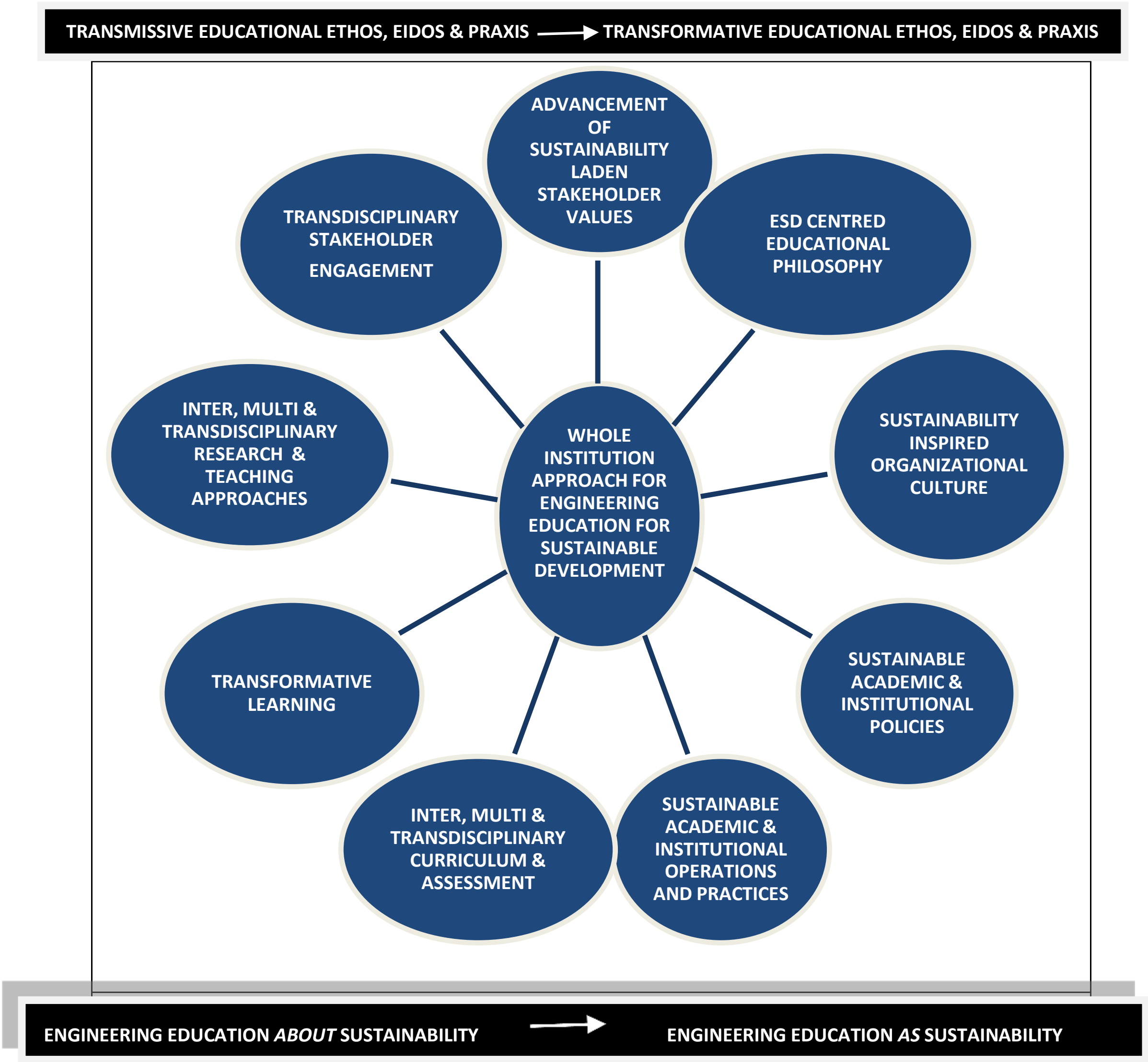


Figure 7.1: Whole Institution EESD Approach

The manner in which these two original contributions can impact upon the development of undergraduate engineering education for sustainable development in Malaysia are discussed in the section that follows.

8.2 Implications of study

The guidelines to incorporate sustainable development competences holistically within undergraduate engineering programme outcomes and common module learning outcomes (Table 6.1) and the whole institution EESD approach framework (Figure 7.1) have benefits for stakeholders, the curriculum, pedagogy, the university and engineering education in Malaysia as a whole.

The proposed guidelines and framework will firstly be instrumental to the Ministry of Education. It will particularly be beneficial to them in formulating sustainability focused higher educational philosophies and practices. As findings of the study suggest, 66.7% of EAC's programme accreditation criteria is sustainability related. However, there is insufficient information provided for institutions of higher learning on ways in which sustainability can be included. The guidelines and EESD framework proposed through this study can thus benefit the EAC and universities. For the EAC, the guidelines and framework can be used as a basis to develop systemic criteria and policies that can aid universities to develop outcomes for successful programme accreditation.

Universities wanting to incorporate sustainable development within its curriculum, assessment, pedagogy, academic and institutional practices, organizational culture and educational philosophy based on holistic and whole institution paradigms, will also find the guidelines and EESD framework instrumental. This is because the guidelines and framework proposed provide specific sustainable development competences and areas universities could look into to incorporate sustainability within engineering programme outcomes, university programme outcomes as well as academic and institutional practices.

As the findings of this study suggest, academicians of undergraduate engineering programmes are agreeable to incorporating sustainable development within the modules they teach and assess. However, insufficient curriculum development support and pedagogical training impede their ability to do so. The guidelines proposed through this study could thus serve as a strategy they could employ to strategically teach, assess and practice EESD.

As the guidelines and framework were developed with input from the engineering industry, it provides universities with a better understanding of the sustainability competences the engineering industry requires of its graduate engineers. The proposed guidelines will thus be useful for the EAC, universities and academicians to develop industry relevant undergraduate engineering programmes and modules to prepare industry ready engineering graduates.

Besides the guidelines and EESD framework, findings of this study also highlight various EESD related curricula, pedagogical, academic, institutional, research and professional development issues that could hamper the incorporation of sustainability. These limitations, and its consequences, will assist universities and academicians gain a better insight of elements to focus upon or avoid if they were to incorporate EESD or ESD within academic policies and practices.

8.3 Limitations of the study

As with all research, the present study was also conducted within several limitations. Firstly, the study was conducted as a single case study of an undergraduate engineering programme of a Malaysian university. The postgraduate engineering context was not included in the study, given the time frame of the study. Given the aims of the study, and the stipulated duration to complete this research, the single case study approach was deemed most suitable to obtain the data required within the permissible time frame of the study.

Respondents of the study consisted of multiple levels of stakeholders of the Malaysian higher education sector, ESD experts and ESD practitioners. For the purpose of this research, the higher education stakeholder respondents were limited to the immediate stakeholders of the university, namely its academicians, final year undergraduate engineering students, university management and members of the Malaysian engineering industry. Student stakeholders were additionally narrowed down to those in the final year of their undergraduate engineering studies, as they were nearing completion of the programme.

Data was collected multiple ways i.e. through surveys, interviews and documents. Data gathered through documents was nevertheless limited to the university's vision and mission statements, undergraduate engineering programme objectives and common undergraduate engineering module learning outcomes. Data gathering through undergraduate module learning outcomes was limited to the common undergraduate modules as these were compulsory modules all engineering students had to complete to be able to graduate from the undergraduate engineering programme.

8.4 Recommendations for future research

Future work could explore the effectiveness of the EESD framework developed in the present study. As the framework in the present study was developed as an integration or evaluation tool, it would therefore be interesting to gauge how effective it is. Suggestions provided by industry practitioners, ESD experts and practitioners on expanding the scope of the competences could be used as a useful starting point for this purpose.

Researchers may also want to explore perspectives of first, second and third year undergraduate engineering student stakeholders, instead of just those in the final year of their studies. A comparison between final year and non-final year undergraduate engineering students could be a possible angle to investigate using this approach. Researchers could also focus on postgraduate engineering programmes.

As the present study focused upon a single case study of a private Malaysian engineering university, future research can look into conducting the same study in other private engineering universities in the country, using a comparative case study approach. Alternatively, the study could also be conducted at Malaysian public universities that offer engineering programmes. Comparisons could then be made between findings from the public and private universities.

While this study focused upon the development of an EESD framework for Malaysian undergraduate engineering programmes as a whole, future studies may want to look into the development of similar frameworks for specific engineering disciplines. Such frameworks should address sustainable engineering elements unique to the engineering discipline concerned.

It would also be interesting to investigate the prevalence of sustainable development in non-engineering courses such as the arts, humanities and social sciences. Such studies are limited within the Malaysian context.

8.5 Conclusion

The eight chapters in this thesis unfold higher education stakeholders' perspectives on EESD in Malaysia. The study was driven by three research questions, using a mixed methods research methodology. Respondents included undergraduate engineering education stakeholders, ESD experts and practitioners. Two novel contributions have been proposed through this study, namely (a) guidelines on the holistic incorporation of sustainable development competences, and (b) a whole institution EESD framework.

As an educator and researcher, this study has helped me understand the intricacies that should go into the planning and implementation of sustainability focused educational programmes that are holistic and whole institution centered. It is hoped that the findings of this study would provide educators and administrators of undergraduate engineering programmes in Malaysia useful insights to deliver and manage the inclusion of sustainable development and ESD within their universities.

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