A SUSTAINABLE FRAMEWORK FOR ASSESSING THE ENGINEERING ACCREDITATION COUNCIL'S PROGRAMME OUTCOMES

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DEDICATION

To my wife, son and daughters

(Thana, Dylan, Eesha, Reyna and Allie)

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ABSTRACT

The Engineering Accreditation Council (EAC) has introduced Outcome-based Education (OBE) in its accreditation manual in 2005. Since then, the assessment of engineering programme outcomes has seen a new paradigm in its implementation. After over a decade of implementation, issues associated with the assessment of programme outcomes are still prevalent among Malaysian Higher Learning Institutions (HLIs). The programme outcomes stipulated in the EAC's accreditation manual serve as a benchmark for engineering programmes in Malaysia and other Washington Accord's signatory countries. Despite this, most accreditation bodies do not stipulate any specific programme assessment model to allow for innovation and creativity among HLIs. Initial investigations underline the diversity of assessment model employed by the accreditation agencies in each member of the Washington Accord. This research investigates the characteristics of different types of assessment model and the reasons for adoption of a specific assessment model by the HLIs (RQ1). This is followed by investigating the challenges and drivers experienced by the HLIs, panel reviewers and academic staff in implementing these assessment models (RQ2). It applies the concepts of sustainable assessment and education that resonate with the definition of sustainable development defined by the World Commission on Environment and Development of the United Nations. In order to answer the research questions, a qualitative methodology comprising in-depth interviews with 18 participants and analysis of documents from EAC and two accreditation bodies in the Washington Accord were carried out. A constant comparative method via inductive data coding process was employed in identifying, analysing and reporting the emerging themes within the data. The analysed data was systematically organised using Strauss and Corbin's 1990 paradigm model. The paradigm model highlights the need to: 1) adopt performance criteria for programme outcomes to improve constructive alignment; 2) adopt culminating assessment model for simplicity, effectiveness, reliability and sustainable efforts; 3) change the mindset and increase exposure to assessment among academic staff; 4) obtain support from accreditation body in providing trainings and reducing the workload of assessment; 5) engage in robust initiatives from HLIs in improving the implementation of outcome assessment; 6) work with committed and enthusiastic institutional leaders; and 7) provide reliable outcome-based support system. Hence a sustainable framework for assessing EAC's programme outcomes was proposed based on these findings.

ABSTRAK

Majlis Akreditasi Kejuruteraan (EAC) telah memperkenalkan Pendidikan Berasaskan Hasil Pembelajaran (OBE) dalam manual akreditasinya pada tahun 2005. Sejak itu, penilaian hasil pembelajaran program kejuruteraan telah menunjukkan paradigma baru dalam pelaksanaannya. Selepas lebih satu dekad, pelaksanaan isu-isu yang berkaitan dengan penilaian hasil program masih diperkatakan di kalangan Institusi Pendidikan Tinggi Malaysia (HLI). Hasil program yang digariskan dalam manual akreditasi EAC menjadi penanda aras bagi program kejuruteraan di Malaysia dan negara-negara Washington Accord yang lain. Walau bagaimanapun, kebanyakan badan akreditasi tidak menetapkan sebarang model penilaian program khusus untuk membolehkan inovasi dan kreativiti di kalangan HLI. Penyelidikan awal menggariskan kepelbagaian model penilaian yang digunakan oleh agensi akreditasi ahli Washington Accord. Kajian ini mengkaji ciri-ciri pelbagai jenis model penilaian dan sebab-sebab penggunaan model penilaian spesifik oleh HLI (RQ1). Ini diikuti dengan mengkaji cabaran dan faktor kejayaan yang dilalui oleh HLI, panel penilai serta kakitangan akademik dalam melaksanakan model penilaian ini (RQ2). Ia menerapkan konsep penilaian dan pendidikan lestari yang mengguna pakai definisi pembangunan lestari yang ditakrifkan oleh Suruhanjaya Dunia mengenai Alam Sekitar dan Pembangunan Pertubuhan Bangsa-Bangsa Bersatu. Dalam menjawab persoalan kajian, satu metodologi kualitatif yang terdiri daripada wawancara secara mendalam dengan 18 orang peserta serta analisa dokumen dari EAC dan dua badan akreditasi di Washington Accord telah dilaksanakan. Kaedah perbandingan tetap melalui proses pengekodan data induktif digunakan untuk mengenal pasti, menganalisis dan melaporkan tema yang muncul dalam data. Data dianalisis secara sistematik menggunakan model paradigma Strauss dan Corbin 1990. Model paradigma menekankan perlunya: 1) mengadaptasi kriteria prestasi untuk hasil program bagi memperbaiki penjajaran yang konstruktif; 2) menerapkan model penilaian puncak untuk kesederhanaan, keberkesanan, kebolehpercayaan dan usaha mampan; 3) mengubah pemikiran dan meningkatkan pendedahan kepada penilaian di kalangan kakitangan akademik; 4) mendapatkan sokongan daripada badan akreditasi dalam menyediakan latihan dan mengurangkan beban kerja penilaian; 5) menghasilkan inisiatif yang mantap dari HLI dalam meningkatkan pelaksanaan penilaian hasil; 6) bekerja dengan pemimpin institusi yang komited dan bersemangat; dan 7) menyediakan sistem sokongan berasaskan hasil yang boleh dipercayai. Oleh itu, rangka kerja yang mampan untuk menilai hasil program EAC telah dicadangkan berdasarkan penemuan ini.

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LIST OF ABBREVIATIONS

ABET	-	Accreditation Board for Engineering and Technology, Inc.
BEM	-	Board of Engineers Malaysia
CEAB	-	Canadian Engineering Accreditation Board
CGPA	-	Cumulative Grade Point Average
CO	-	Course Learning Outcomes
CQI	-	Continuous Quality Improvement
EAC	-	Engineering Accreditation Council
ELO	-	Exit Level Outcome
EC2000	-	Engineering Criteria 2000
ECSA	-	Engineering Council South Africa
EGAD	-	Engineering Graduate Attribute Development
GPA	-	Grade Point Average
HLI(s)	-	Higher Learning Institutions
iCGPA	-	Integrated Cumulative Grade Point Average
IEA	-	International Engineering Alliance
MOHE	-	Former Ministry of Higher Education of Malaysia
NZ	-	New Zealand
OBE	-	Outcome-based Education
PEO	-	Programme Educational Objectives
PO	-	Programme Outcomes
RQ	-	Research Question
WK	-	Knowledge Profile

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CHAPTER 1

INTRODUCTION

1.1 Overview

The programme outcomes or synonymously known as graduate attributes stipulated in the International Engineering Alliance's (IEA) graduate attributes and professional competencies serve as a benchmark of standards for engineering education to Higher Learning Institutions (HLIs) in Malaysia as well as other signatory countries of the Washington Accord (IEA, 2013; EAC, 2017). These programme outcomes have been designed to prepare engineering graduates for future technological and societal changes, and help them acquire new knowledge that can be applied to new problems of the 21st century (IEA, 2013; EAC, 2015a). Over the years, there are various reports that confirmed the importance of direct assessment of learning outcomes in higher education (Coates, 2014). For instance, a large and international scale project by the Organisation for Economic Co-operation and Development's (OECD) titled "Assessment of Higher Education Learning Outcomes" (OECD, 2010; OECD, 2012; OECD, 2013) that directly assesses students' skill levels who are in the final year of their undergraduate programmes. The project concluded that creating and implementing a "learning outcomes approach" is not an easy task which depends on individual country's conditions and cultural settings. Ironically, learning outcomes are often viewed as a threat that will streamline education and limit academic freedom (OECD, 2011).

The Washington Accord has grown from six signatories in 1989 to a well-sought-after organisation with Peru being the recent 20th signatory in 2018 (IEA, 2018). Despite the growing number of signatory countries and widespread of accreditation of engineering programmes, with regard to assessing the programme outcomes in the Washington Accord, most accreditation bodies do not specify any specific model to encourage innovation and creativity in the assessment (CEAB, 2014; ECSA, 2014; ABEEK, 2015; ABET, 2017a; EAC, 2017). Similar flexibility is also practiced in Malaysia, however, the absence of a specific model for assessing engineering programme outcomes was believed to be one of the reasons that majority of the assessment models employed by the HLIs are unable to reflect the true outcomes of their students (EAC, 2015b). Recognising this, the Engineering Accreditation Council Malaysia (EAC) created a document titled, "Accreditation report moderation checklist" that documents the requirements of an effective assessment model for panel reviewers to assist HLIs to overcome the challenges in the implementation (EAC, 2015b).

Besides the absence of a specific assessment model, academic staff of the engineering faculties are challenged by a number of implementation issues. These issues can be summarised by Biggs' (1995) three main factors hindering the change of assessment practices among the academic staff. The first is the "know-how", the academic staff may not know how to improve their assessment techniques. Second is the probability that "they don't know that they don't know". If an academic staff has a fixed mindset and believe that he or she should teach, learn, and assess by certain means, then the person would not see that there is a problem. And finally, the academic staff have the institutional social system to overcome. This social system is the various collegial, accountability, and managerial agendas, that exerts pressure on the assessment model in use (Reid, 1987).

The present research applied the concept of sustainable development defined by the World Commission on Environment and Development of the United Nations (Brundtland, 1987). Boud (2000) and Boud and Falchikov (2006) developed the concept of sustainable assessment that resonates with the definition of sustainable development which was reframed to focus on learning. Sustainable assessment is defined as the assessment 'that meets the needs of the present and [also] prepares students to meet their own future learning needs' (Boud, 2000). The concept focuses on the importance of assessment practices to equip students for the challenges of learning and practice that they will face in the workplace once their current episode of learning is completed at the HLIs (Boud & Soler, 2016). Beck et al. (2013) explained that though sustainability in education can be interpreted as a feature of educational systems, it is not just about the sustainability of physical environment but also includes the sustainability of educational practices (Beck et al., 2013). These educational practices are needed in order to prepare students for the challenges of learning and practice that they will face in the workplace which is in-line with the programme outcomes defined by the IEA and EAC whereby engineering students must be prepared to function in a complex society and solve complex problems (IEA, 2013; EAC, 2015b).

In order to form a framework for assessing programme outcomes, the sustainability of academic staff's efforts must also be considered in addition to the sustainable assessment of educational practices as described above. In sustainable education described by Fullan (2007), academic staff and students sustain each other's learning process. In Fullan's terms, the key to sustainable education systems is to situate the energy of academic staff and students as the central driving force. What has been learnt perpetually fuels one's own, and the others', new learning (and the motivation to go on learning); as a result, institutions become learning communities that eagerly exploit the vast potential of social interaction to keep the energy flowing (Van den Branden, 2012). In this way, energy for learning becomes renewable energy.

From an engineering education perspective, this research emphasised on the need to investigate the implementation gaps in assessing engineering programme outcomes and the importance of addressing these gaps to reflect students' real performances in the twelve programme outcomes stipulated by EAC. The theory of sustainable development (Brundtland, 1987; Boud, 2000; Boud & Falchikov, 2006; Fullan, 2007) will be used to guide this research with the aims of: (1) producing sustainable engineering graduates who are able to solve future engineering problems; and (2) achieving sustainable academic staff' efforts by reducing the burden due to assessment practices. In order to achieve these, the present research will address the choice of a specific model for assessing engineering programme outcomes and the issues faced by the academic staff of engineering faculties in implementing the assessment model.

1.2 Background of the Research

This section provides the background of the adoption of Outcomes-based Education (OBE) in Malaysia followed by the challenges of assessing programme outcomes. It ends with the concept of sustainable development which is believed to be able to resolve the challenges.

1.2.1 Malaysia's Entry to the Washington Accord and Outcomes-Based Education Implementation

The Washington Accord is an agreement between the bodies responsible for accreditation or recognition of professional engineering undergraduate degree programmes in each of its signatory countries. The agreement recognises the substantial equivalency of programmes accredited by those bodies and recommends that graduates of accredited programmes in any of the signatory countries be recognised by the other countries as having met the academic requirements for entry to the practice of engineering (IEA, 2011a). In June 2009, the Board of Engineers Malaysia (BEM) was admitted to be the full signatory of the Washington Accord for

Malaysia in June 2009 after serving as provisional member since 2003; and the 13th signatory of the current 20 signatories of the accord (IEA, 2018).

EAC is a body delegated by BEM to accredit engineering degree programmes. The latest EAC's accreditation manual was released in 2017 and has seven assessment criteria for accrediting engineering degree programmes. The programme outcomes stipulated in the accreditation manual are one of the assessment criteria and are a common set of attributes shared by all HLIs in Malaysia and other Washington Accord's signatory countries. The other assessment criteria are programme objectives, academic curriculum, students, academic and support staff, facilities and quality management systems (EAC, 2017). The accreditation manuals have undergone four revisions since 2003 that mostly evolved around the programme outcomes due to the global emphasis on OBE and the latest developments in engineering education such as complex engineering problem solving (EAC, 2015a).

In the global scenario, similar events described above had taken place. The Accreditation Board for Engineering and Technology, Inc. (ABET) of the United States introduced an accreditation manual, i.e., the Engineering Criteria 2000 (EC2000) in 1995 where it moved from a process-based quality assurance on evaluating programme's characteristics to evaluating and improving the intellectual skills and capabilities of graduates (Prados, 2005). In 2008, the Canadian Engineering Accreditation Board (CEAB) introduced outcomes-based assessment as part of its accreditation criteria. During the transition to outcomes-based assessment, CEAB initiated the project, the Engineering Graduate Attribute Development (EGAD) to assist the Canadian faculties and schools of engineering to implement the outcomes-based assessment (CEAB, 2012). The United States and Canada are two of the founding members of the Washington Accord, whereby their assessment practices and strategies are very much sought after by other countries as benchmark (Liew et al., 2014).

The assessment of programme outcomes is required by EAC as stipulated in its accreditation manual. In the 2017 EAC accreditation manual, engineering programmes for which accreditation is sought must consider EAC's programme outcomes in designing the curriculum. The accreditation manual (EAC, 2017) listed three requirements: (1) the curriculum, the teaching-learning activities and assessment methods shall support the attainment of the programme outcomes, i.e., they must be constructively aligned. This requirement has strong connection to constructivist philosophy. The philosophy aligns curriculum, pedagogy and assessment when it is fully understood and implemented by the academic staff (Cooper, 2007); (2) the attainment of the programme outcomes must also be assessed and use for Continuous Quality Improvement (CQI); and (3) the engineering programmes must show a high of stakeholders' involvement in the abovementioned process.

1.2.2 The Challenges of Assessing Programme Outcomes

Over the years, various studies around the world (Gurocak, 2009; Passow, 2012; Cicek et al., 2014; Coates, 2014) showed that the assessment of programme outcomes is arguably the most important criterion with regards to OBE that emphasises on improving the intellectual skills and capabilities of graduates (IEA, 2013; EAC, 2015a). It was noted that most accreditation bodies in the Washington Accord do not stipulate any specific model in the assessment of programme outcomes to allow for innovation and creativity. It is the sole responsibility of the HLIs to develop and establish suitable and appropriate outcome measures for their programmes (CEAB, 2014; ECSA, 2014; ABEEK, 2015; ABET, 2017a; EAC, 2017). However, the extent of guidelines in assessing programme outcomes provided by the accreditation bodies may differ from country to country, for examples, the CEAB provides guidance in the form of performance indicators for each programme outcome (CEAB, 2014) while the Engineering Council South Africa (ECSA) provides description on each programme outcome (ECSA, 2014).

During Malaysia's progression towards full signatory of the Washington Accord, a number of changes were introduced in the EAC's accreditation manuals. This prompted several dialogues between by the Malaysian Council of Engineering Deans and EAC in 2008 and 2010 to discuss issues related to accreditation (EAC, 2010). The Engineering Deans were concerned that the accreditation manual outlined vague requirements in regards to accrediting engineering programmes. They also highlighted the burdensome responsibilities and massive amount of preparation and collection of data required for accreditation. Apart from the preliminary concerns of the Engineering Deans, the researcher's personal communication with the past Director of the Engineering Accreditation Department (personal communication, September 2, 2015) revealed that HLIs were hampered with challenges in assessing the programme outcomes. The OBE assessment models employed by the HLIs were unable to reflect the true outcomes of their students. There were underlying problems of the models such as poor constructive alignment, inappropriate use of assessment tools for different types of outcome, and failure to apply the results of assessment for programme improvement. Recognising these issues, the Accreditation Report Moderation Checklist for Panel Reviewers issued by EAC in 2015 highlighted its concern on assessing programme outcomes that reads as:

> "The direct and explicit assessment of each of the twelve programme outcomes stipulated in the EAC Manual 2012 and the harmonisation of the programme outcomes to bring about a holistic programme improvement need to be continually demonstrated."
>
> (EAC, 2015b)

EAC through the above statement outlines that the assessment of programme outcomes must reflect the true students' outcomes. In addition, the results of the assessment must be used for CQI. Such call for a direct and explicit assessment of each of the programme outcomes by EAC was carried out because various OBE assessment models adopted by the HLIs did not reflect the true outcomes of students. This has consequently caused a limitation to the holistic programme improvement planned by the institutions (EAC, 2015b).

The abovementioned challenges were further fortified through the researcher's participation in eighteen accreditation visits between 2012 and 2016. The researcher was involved in the capacity as panel reviewer and head of panel reviewers for electrical and electronic engineering programmes with EAC. Table 1.1 details that the HLIs faced two major issues in the accreditation criterion of programme outcomes: assessment of programme outcomes did not reflect the real outcomes of the students; and outcome attainments were not used in improving their engineering programmes. Therefore, it is evidenced that the assessment of programme outcomes remained as a pressing issue with many Malaysian HLIs.

Table 1.1 The details of the concern or weakness on the criterion of programme outcomes recorded by Higher Learning Institutions visited between 2012 and 2016

Type of institutions	**Month and year of visit (mm/yyyy)**	**Programme outcome attainments not reflecting real outcomes**	**Programme outcome attainments not used for continuous quality improvement**	**Programme outcome attainments not tabulated**	**Limited stakeholder involvement in the assessment and evaluation of programme outcome attainments**
Public	07/2012	-	X	-	-
Public	09/2012	-	X	-	-
International	11/2012	-	-	X	-
Public	05/2013	-	X	-	-
International	09/2013	X	-	-	-
Public	10/2013	-	-	-	-
Private	12/2013	-	-	-	-
Public	01/2014	-	-	-	X
Private	02/2014	X	-	-	-
Private	06/2014	-	X	-	-
Private	03/2015	-	-	X	-
Public	04/2015	X	-	-	-
International	10/2015	X	-	-	-
International	04/2016	X	X	-	-
Public	04/2016	-	X	-	-
Private	09/2016	X	-	-	-
Private	09/2016	X	X	-	-
International	11/2016	X	X	-	X

A comparison with the global scenario was performed in order to identify the gravity of the issue. Literatures indicate that the challenges of assessing programme outcomes at the institutional level have been reported as early as the 1990's. Although ABET places strong emphasis on programme objectives and programme outcomes, many HLIs in the United States misinterpreted the assessment and evaluation requirements due to lack of understanding on the requirements of accrediting engineering programmes (Prados et al., 2005). As a result, a massive amount and unnecessary data was always collected and presented to the accreditation panel reviewers. In addition, the HLIs often failed to perform a meaningful analysis of the results and presented ambiguous plans on the utilisation of data for CQI on their programmes. The lack of understanding on the requirements of accrediting engineering programmes has caused increased workload to the academic staff (Williams, 2002; Howell et al., 2003; Shuman et al., 2005; Gurocak, 2009) due to the evidence needed in order to fulfil the requirements of accreditation (Rogers, 2000). Briedis (2013) further indicated that the use of inappropriate assessment tools employed by the HLIs, and unsustainable efforts and resistance from the academic staff are among the challenges faced by the HLIs in preparing for accreditation. The above-mentioned are a part of the three main factors impeding change in assessment among the academic staff pointed out by Biggs (1995). In this context, the academic staff may not know how to improve their assessment techniques, for examples, the lack of understanding on assessment requirements and the use of inappropriate assessment tools mentioned earlier. Furthermore, they may have a fixed mindset, believing that they should teach, learn, and assess by certain means, then they would not see that there is a problem hence strongly resist to change in assessment schemes. And finally, they have the institutional social system to deal with, the various collegial, accountability and managerial agendas that exert pressure on the assessment system in use.

The preliminary findings and literature reviews have revealed the seriousness of the issues engulfing the accreditation of engineering programmes. The assessment of programme outcomes is a long-standing issue faced by many HLIs in Malaysia since the introduction of OBE by IEA in 2005 (IEA, 2013). After over a decade of implementation, issues associated to the assessment of programme outcomes are still prevalent.

1.2.3 Sustainable Framework

The proposed framework for assessing programme outcomes aims to address sustainability from two aspects: assessments that equip students for the challenges of learning and practice that they will face in the workplace which is termed as sustainable assessment; and academic staff's efforts on administering the assessments and all associated tasks for students, termed as sustainable effort.

The concept of ''sustainable development'' was coined in the Brundtland report issued by the World Commission on Environment and Development of the United Nations (Brundtland, 1987). Boud (2000) and Boud and Falchikov (2006) developed the concept of sustainable assessment based on the definition of sustainable development which was reframed to focus on learning. They defined sustainable assessment as 'assessment that meets the needs of the present and [also] prepares students to meet their own future learning needs' which commensurate with the programme outcomes defined by IEA and EAC that require engineering graduates to solve complex problems and function in a complex society (IEA, 2013; EAC, 2015b). In administering sustainable assessment, the sustainability of academic staff's efforts must also be considered as the academic staff and students sustain each other's learning process (Fullan, 2007).

The two aspects of sustainability can be categorised as the principles of sustainable education defined by Van den Branden (2012) as follows:

> "In sustainable education, students acquire what is necessary and useful to address their own, and society's, present and future needs; students acquire these competences to full-blown, sustainable levels, that is, to such an extent that the competences are truly incorporated and can be further developed later on in life. The natural resources that are available (the students' talents, prior knowledge, learning potential, and learning motivation and the educators' competencies, experience, and motivations) are tapped as renewable resources rather than being wasted or depleted."
>
> (Van den Branden, 2012)

It is clear that the quotes stressed on the importance of assessment to prepare students to meet society's present and future needs, and to be lifelong learners, it is also essential that the natural resources to be renewable such as educators' competencies, experience, and motivations in administering the assessment.

1.3 Statement of the Problem

The programme outcomes assessment models practised by the HLIs in Malaysia are unable to reflect students' real performances in the twelve programme outcomes stipulated by EAC (EAC, 2010; EAC, 2015b). This shortcoming is jeopardising the aim of EAC to produce engineering graduates who are prepared for future technological and societal changes, and able to acquire new knowledge and apply to new problems (IEA, 2013; EAC, 2015b). The possible underlying issues identified from the literature review and accreditation visits by the researcher are absence of a specific model for assessing engineering programme outcomes, lack of understanding in assessment requirements, resistance to change, feeling of burden and unsustainable efforts among academic staff, along with poor understanding of constructive alignment (Gurocak, 2009; Briedis, 2013; Cicek et al., 2014; EAC, 2015b; Kardanova et al., 2016). With the exception of absence of a specific assessment model, the remaining issues are found to be consistent with the three factors impeding the change in assessment described by Biggs (1995).

The aim of sustainable assessment described by Boud (2000) and Boud and Falchikov (2006) is coherence to the programme outcomes defined by the IEA and EAC that is to produce engineering graduates who are able to function in a complex society and solve complex problems (IEA, 2013; EAC, 2015b). However, the missing link in the current assessment practices in higher education is that it did not equip students well for a lifetime of learning and the assessment challenges they would face in the future (Boud & Falchikov, 2006). In realising this, the sustainability of academic staff's efforts must be considered as academic staff and students sustain each other's learning process as described by Fullan (2007).

The issues arisen from the choice of assessment model (due to the absence of a specific assessment model) by Malaysian HLIs, and the implementation issues of a specific assessment model (discussed above) experienced by the HLIs and their academic staff ought to be investigated in order to form a sustainable framework for assessing engineering programme outcomes.

1.4 Purpose of the Research

The purpose of this research is to qualitatively explore the assessment practices on engineering programmes in Malaysia. Panel reviewers, programme owners and academic staff' views on various assessment models, and challenges and drivers in the implementation of these models are discussed. Finally, a sustainable framework for assessing programme outcomes is proposed. Sustainable framework as a result of the findings of this research are expected to be useful for stakeholders such as HLIs, faculties, panel reviewers as well as EAC to prepare engineering students to solve complex engineering problems in the workplace and function effectively in the complex society without excessive burden to the academic staff on administering and executing the assessment practices.

1.5 Objectives of the Research

The research attempts to investigate the underlying issues in assessing programme outcomes. It will propose a sustainable framework to address these issues, sustainable in terms of effort from the academic staff, reflective of students' outcomes, and capable of preparing engineering graduates in Malaysia for future technological and societal changes, and able to acquire new knowledge and apply to new problems.

In order to do this, the following two objectives were formulated:

i. To investigate the strengths and weaknesses of the assessment models of engineering programme outcomes employed by selected Malaysian HLIs and Washington Accord's signatory countries.

ii. To investigate the challenges and key drivers experienced by Malaysian HLIs in implementing their assessment models.

Based on the finding, it is the intention of the researcher to propose a sustainable framework for academic staff, faculties and HLIs to assess engineering programme outcomes.

1.6 Research Questions

To achieve the stipulated research objectives, the following research questions were derived:

Objective 1: To investigate the strengths and weaknesses of the assessment models of engineering programme outcomes employed by selected Malaysian HLIs and Washington Accord's signatory countries.

Research Question 1 (RQ1):

i) What are the positive and negative characteristics of the assessment models of engineering programme outcomes employed by selected Malaysian HLIs and Washington Accord's signatory countries?

ii) Why is a specific assessment model adopted by the HLIs?

Objective 2: To investigate the challenges and key drivers experienced by Malaysian HLIs in implementing their assessment models.

Research Question 2 (RQ2):

i) How do the challenges experienced by Malaysian HLIs affect the implementation of the assessment models?

ii) Why are the key drivers experienced by Malaysian HLIs effective in the implementation of the assessment models?

The answers lead to the development of a framework represents how sustainability can be achieved for engineering students and engineering educators.

1.7 Significance of the Research

The first significance of the research is it qualitatively explores the challenges in implementing EAC's programme outcomes to provide a body of literacy work. An insight on how basic qualitative research in constructivist paradigm is being employed to understand how the participants of this research make sense and interpret the types of assessment models, and challenges and drivers in assessing programme outcomes that affect the sustainability with regards to the assessment of programme outcomes. This research also bridges the gap of qualitative research particularly in the context of academic staff's challenges in programme outcome assessment. The application of inductive research approach has comprehensively addressed the research questions. The triangulation and convergence of findings through the perspectives from various participants as well as extract from accreditation visits and document analysis were the result of a comprehensive qualitative design adopted in this research. In addition, the systematic application of constant comparative method through the open, axial and selective coding procedure in which the data was analysed and resulted in the development of a paradigm model. Finally, the research contributed to the body of knowledge by applying the paradigm model to portray the results of the qualitative analysis. The paradigm model provides a holistic view of the inter-relationship between themes and subthemes which emerged in the whole process of qualitative analysis.

The second significance of the present research is to present a qualitative analysis on the assessment practices in assessing programme outcomes in Malaysia. The present research identified the assessment models used by some HLIs in Malaysia and Washington Accord's signatory countries, and analysed the strengths and weaknesses of these models. The engineering courses used to assess programme outcomes were also identified with justification provided. The choice of assessment models and engineering courses that institutions or engineering faculties made will have significant impact on the sustainability of academic staff's effort on assessment. The challenges and key drivers in the assessment of programme outcomes were revealed through interviews with academia, programme owners, office bearers of accreditation body and senior panel reviewers. The strategies proposed in the paradigm model would be able to assist the academic staff to redesign and realign the existing curriculum to meet the outcomes required by the accreditation body. In addition, they would be able to experience lower workload required in performing assessment by focusing on selected courses. As a result, they would appreciate the value of assessment with the greater understanding of the assessment requirements. Likewise, this research would be able to assist HLIs to provide better support to the academic staff, consequently, issues associated with programme outcome assessment such as workload, knowledge gap and assessment culture can be avoided. Ultimately, the HLIs will benefit from the greater motivation and enthusiasm among the academic staff that result in successful implementation of sustainable framework. Finally, the proposed strategies in the paradigm model would promote greater direction from the accreditation bodies by reducing the mismatch of expectations with the HLIs and workload with regards to assessment, and promoting sustainable engineering graduates through sustainable assessment. Recognition of these challenges and key drivers will enable HLIs, programme owners, academic staff and accreditation bodies to avoid or improve situations that affect the sustainability of the assessment of programme outcomes.

The third significance is to conduct engineering education research on the assessment of programme outcomes which is less available in the Malaysian context. This research was conducted in Malaysia with some international flavours. The first group of the participants is the senior panel reviewers from the United States, Taiwan and South Africa with the experience of reviewing the status of Malaysia in the Washington Accord in 2015. The second group of participants is academia who have or had been the office bearers of the Engineering Accreditation Department, the accreditation unit of EAC. And the third group of participants is academia who have or had held administration posts (dean, deputy dean, head of department, etc.) within their universities and are senior panel reviewers of EAC. All the participants have experience in accreditation of engineering programmes and possess significant knowledge on assessment of programme outcomes. Review of the literature indicates the lack of qualitative study that involves academia who are of that experience and portfolio. The research sets to provide a new literature to the Malaysian higher education setting and promote sustainable assessment of programme outcomes.

1.8 Scope of the Research

The scope of the research is limited to the criterion of programme outcomes of the seven criteria stipulated in the accreditation manual (EAC, 2017). The other assessment criteria are programme objectives, academic curriculum, students, academic and support staff, facilities and quality management systems. Unlike other criteria which could vary from one country to another, the programme outcomes are a common set of attributes shared by all signatory countries in the Washington Accord, including Malaysia.

Likewise, there is also a limitation in terms of the level of engineering programmes, whereby only undergraduate engineering degree programmes which are qualified to seek for accreditation from EAC are investigated. These programmes are of four to five years duration of study, depending on the level of entry as stipulated in the Washington Accord (IEA, 2013).

Finally, due to the wide scope of sustainable assessment, the present research will only focus on the first two principles that deal with the setting of standards and criteria of assessment at the faculty and institutional level. The subsequent two principles deal with collaboration between students and academic staff, and students' self-monitoring of their own progress which are more micro in nature.

1.9 Conceptual Framework

As discussed in the research background, the two aspects of sustainability, i.e., sustainable assessment and sustainable effort, absence of a specific model in assessing programme outcomes and implementation issues experienced by the academic staff will be the basis of the framework. The principles of sustainable assessment theory by Boud (2000) and Boud and Falchikov (2006) will be used as a background to refer to these associated issues.

Sustainable assessment theory is an emerging approach to assessment complementing the existing summative and formative assessment methods (Boud 2000; Boud & Falchikov, 2006). The idea is that assessment needs to be brought into alignment with teaching and learning for the purpose of equipping graduates to assess their abilities to learn in a variety of non-academic, relatively complex situation after graduation (Beck et al., 2011). Therefore, Beck et al. (2011) reckoned that sustainable assessment is part of a 'constructive alignment' between the teaching and learning and assessment tasks promoted by Biggs (2003). However, the missing link in Biggs' model of constructive alignment is the current assessment practices in higher education did not equip students well for a lifetime of learning and the assessment challenges they would face in the future (Boud & Falchikov, 2006). Sustainable assessment theory has four (4) principles (Boud, 2000; Boud & Falchikov, 2006): (1) focus on long-term learning outcomes that are applicable not only to course activities but also to the workplace; (2) explicit criteria defining student outcomes; (3) co-participation by students and academic staff in making judgements in assessment activities; and (4) development of devices for self-monitoring and judging progression towards goals. These principles will be explained in a greater detail in this section.

The complex engineering problems defined by the IEA are identical to the nature of the problems arose in the industry (Liew et al., 2019). From that standpoint, EAC's programme outcomes encompass the nature of the problems which engineering students must be trained in order to adapt to the industrial sector's problems and solutions. Hence this is very much commensurate with the first principle of sustainable assessment, "focus on long-term learning outcomes that are applicable not only to course activities but also to the workplace".

The second principle is very much concerned with the performance criteria in assessing EAC's programme outcomes. Literature review indicates that the absence of performance criteria for assessing programme outcomes in the assessment models will not only lead to unsustainable assessment but also create associated issues on sustainability in terms of the academic staff's efforts. For examples, heavy workload and unreasonable expectations in assessment experienced by the academic staff as reported by Brumm et al. (2006), Shay et al., (2008) and Yamayee and Albright (2008). Mohammad and Zaharim (2012) added that absence of performance criteria has resulted in the use of incorrect assessment tools which in turn led to the failure of HLIs to demonstrate effective CQI for improving students' outcomes. Other reported issues are poor constructive alignment (Felder & Brent, 2003; EAC, 2015b; Hamzah & Liew, 2018), resistance from academic staff (Gurocak, 2009) and lack of culture of assessment among academic staff (Anagnos et al., 2008; Briedis, 2013). The abovementioned issues can be summarised under Biggs' (1995) three main factors that hinder the change in assessment among the academic staff and closely related to the sustainability of academic staff's efforts highlighted by Fullan (2007) and Van den Branden (2012) as discussed in the research background.

According to Boud and Falchikov (2006), the third principle is about preparing the students for lifelong learning with the co-participation between students and academic staff. It involves preparing the students to make judgements about their own work and that of others, and to make decisions under uncertain and unpredictable circumstances in which they will find themselves in the future workplace.

Finally, the fourth principle is about developing strategies and devices for the students to judge whether progress is being made towards outcomes. According to Boud (2000), this involves the development of a range of strategies and devices deployed in the process of learning from setting intermediate goals and checking progress at regular intervals, keeping learning journals or to more sophisticated meta-cognitive devices. It is not only necessary to know what are the appropriate standards and criteria defined in the first three principles, however, it is also essential to measure and determine the extent to which students' work meets the standards and criteria (Boud, 2000).

From the above discussion, the first two principles of sustainable assessment deal with the setting of standards and criteria of assessment at the faculty and institutional level whereby the subsequent two principles deal with collaboration between students and academic staff, and students' self-monitoring of their own progress towards stated goals. Due to the wide scope of sustainable assessment, the present research will focus only on the first two principles which are the concerns at the faculty and institutional level.

In addition to the Biggs' (1995) three main factors that hinder the change in assessment among the academic staff, the absence of specific assessment model also contributes to the challenges in the assessment of programme outcomes (CEAB, 2014; ECSA, 2014; ABEEK, 2015; ABET, 2017a; EAC, 2017).

The issues highlighted above are the focus of this research whereby a sustainable framework in assessing EAC's programme outcomes will be proposed to address them. This research focuses on synthesising a sustainable framework for assessing EAC's programme outcomes. The outcomes of this framework are two folds: sustainable engineering graduates who are ready for future technological and societal changes, and able to acquire new knowledge and apply to new problems; and sustainable in terms of efforts, reducing the burden of assessment of programme outcomes experienced by the academic staff.

The conceptual framework in Figure 1.1 represents the visual demonstration of the relationship between the variables under investigation in this research. It shows the analysis of differences between current situation and ideal situation, and learning needs that lead to the framework.

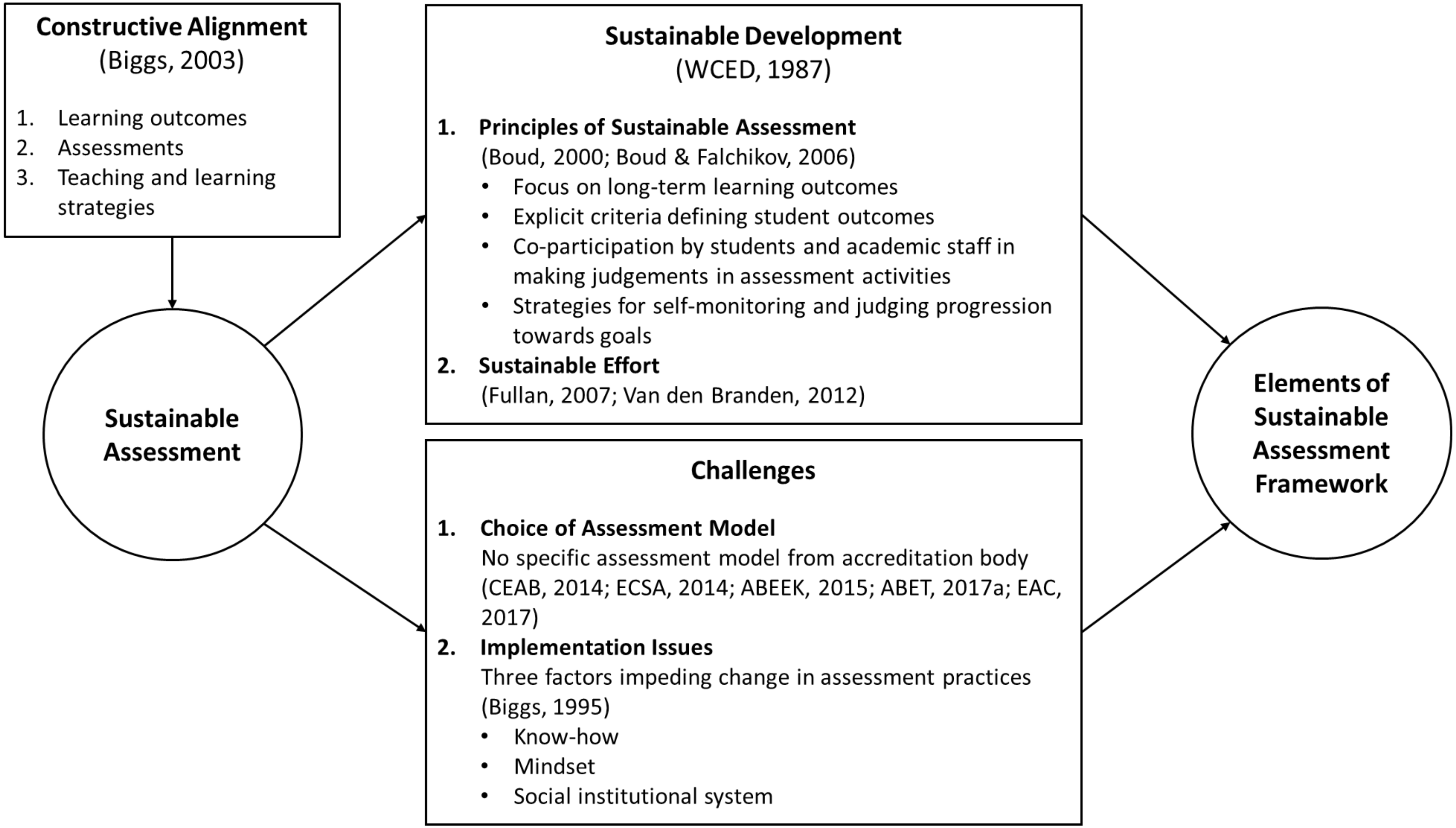

Figure 1.1 Conceptual framework of the research

1.10 Theoretical Framework

As highlighted in previous sections, the aim of engineering programmes is to prepare graduates who are able to adapt to function in a complex society and solve complex problems (IEA, 2013; EAC, 2017). Hence the underlying theory of learning to guide the present research is constructivism, according to which students are assumed to learn cumulatively, and actively interpreting and incorporating new materials with what they already know (Piaget, 1975; Vygotsky, 1978). In another word, student is viewed as an active learner seeks meaning by constructing knowledge rather than by receiving and storing knowledge.

The transformational OBE model proposed by Spady (1994) articulates a holistic constructivist approach to learning. Spady (1994) states that OBE means clearly focusing and organising everything in an educational system around what is essential for all students to be able to do successfully at the end of their learning process. OBE sets clear outcomes for learners that shape the curriculum, assessment techniques and teaching strategies which will enable them to achieve and display the designated outcomes. Spady (1994) promotes heavy emphasis on the use of authentic life contexts, settings, and experiences which commensurate with the engineering students' ability to solve complex problems (IEA, 2013; EAC, 2017). These are viewed as both necessary places where learning should occur and realistic settings in which performances should be carried out.

The main theoretical underpinning of the outcomes-based curriculum is provided by Biggs (2003). The model requires alignment between the three key areas of the curriculum, namely, the intended learning outcomes, assessment and teaching and learning strategies. According to Biggs (2003), non-alignment in the system will lead to poor teaching and surface learning which is signified by unmet expectations, and practices that contradict the pre-defined pedagogies.

Boud and Falchikov (2006) pointed out that the model of constructive alignment as developed by Biggs (2003) must be extended to encompass not only consistency of purpose between the proximate elements of programmes, but to look beyond the point of graduation to seek alignment with longer-term purposes. In this context, the authors proposed a theory on sustainable assessment to complement the existing assessment methods. The theory focuses on the importance of all assessment practices to equip students for the challenges of learning and practice that they will face in the workplace once their learning is completed at the HLIs (Boud & Soler, 2016). The four principles of sustainable assessment defined by Boud (2000) and Boud and Falchikov (2006) are associated with the setting of standards and criteria of assessment at the faculty and institutional level, collaboration between the students and academic staff in assessment activities as well as students' self-monitoring of their own progress towards the stated goals.

In summary, the ideology of constructivism theories of learning emphasises on the ability of the students to elaborate on and interpret information; and the transfer of knowledge is facilitated by authentic tasks related to real-world problems (Piaget, 1975; Vygotsky, 1978). This is in support of the aim of engineering programmes which is to prepare engineering graduates for future technological and societal changes, and help them acquire new knowledge that can be applied to new problems of the 21st century (IEA, 2013; EAC, 2015a).

In order to achieve this, the change within the engineering educational system is required to facilitate learning for learners to reach the desired outcomes. According to Spady (1994), the focus of education ought to be shifted from the educator to learner with the role of educator is to enable and encourage all learners to achieve desired outcomes. Alignment of these desired outcomes with assessment practices and teaching and learning strategies is important in producing graduates with the required programme outcomes at the end of the programme of study (Biggs, 2003). Next, the concept of sustainable assessment requires all assessment practices to be brought into alignment with teaching and learning to allow learners to be actively participating and contributing in the learning process, and equip them for the challenges of learning and practice that they would face in the workplace once their current episode of learning is completed at the HLIs (Boud, 2000; Boud & Falchikov, 2006). The concept of sustainable education described by Fullan (2007) and Van den Branden (2012) is also considered to achieve sustainability in terms of academic staff' efforts, reducing the feeling of burden due to assessment.

The theoretical framework of the present research is illustrated in Figure 1.2.

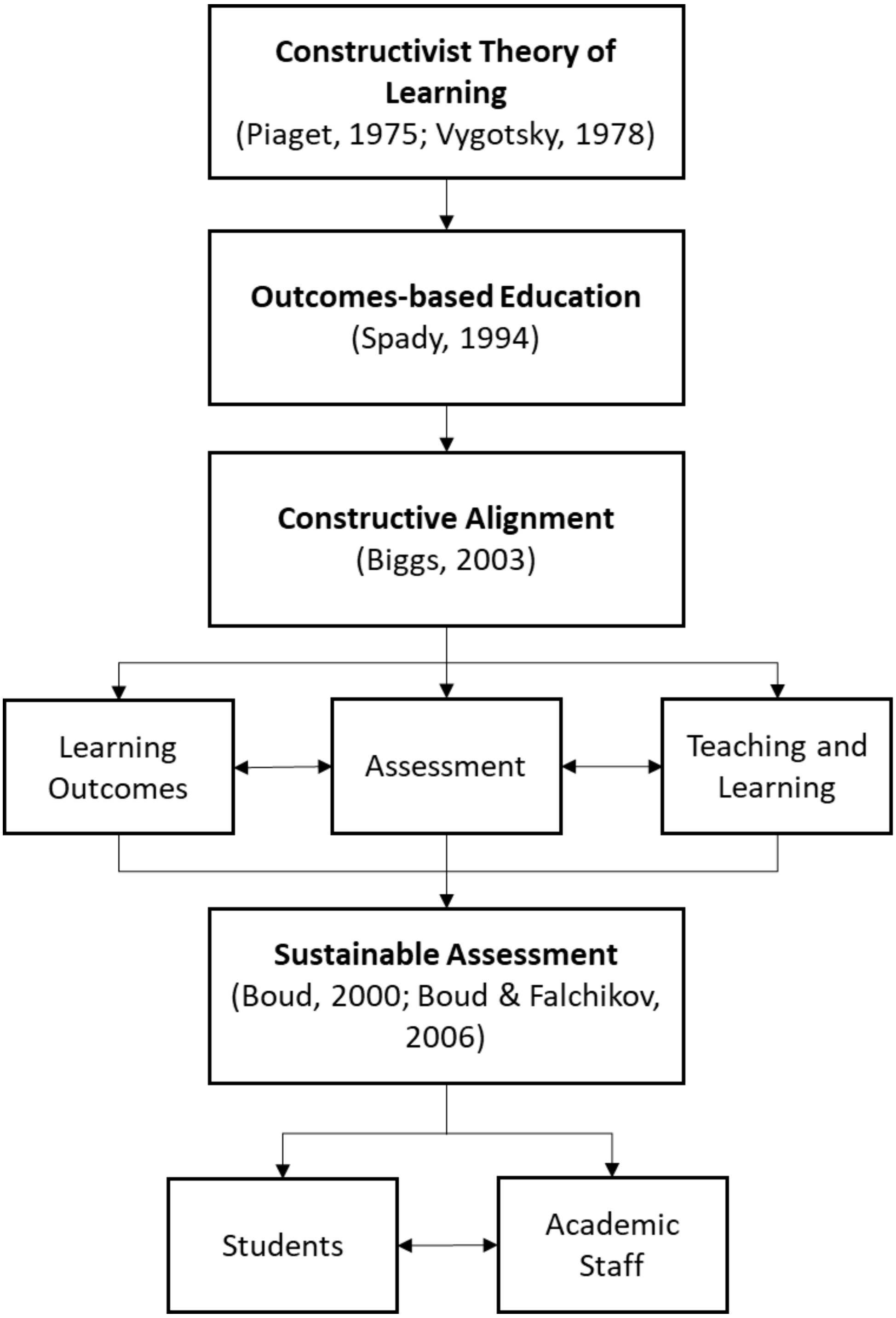

Figure 1.2 Theoretical framework of the research

1.11 Definitions of Terms

This research focuses on the assessment of engineering programme outcomes. The terminologies used in this research are defined and elaborated in this section.

i. Sustainable Assessment

Boud (2000) defined sustainable assessment as "assessment that meets the needs of the present and [also] prepares students to meet their own future learning needs.". In the engineering context, sustainable assessment prepares graduates who are able to solve current and future problems in the workplace, seek information and construct new knowledge.

ii. Outcomes-Based Education (OBE)

OBE is an educational approach that focuses on outcomes, i.e. student achievement that is measurable, proven, and can be improved (EAC, 2012). It is a learner-centred approach to education that focuses on what students should be able to do in the workplace upon completion of their programme.

iii. Programme Outcomes, Exit-level Outcomes, Graduate Attributes and Student Outcomes

Programme outcomes (EAC, 2017), exit-level outcomes (IEA, 2011b), graduate attributes (IEA, 2013) and student outcomes (ABET, 2017a) are often used interchangeably to describe the skills, knowledge and behaviour expected out of a graduate upon completion of an engineering programme. This research will apply the term as proposed by EAC (2017). An example of the definition of programme outcomes is as follows:

> "Programme outcomes are statements that describe what students are expected to know and be able to attain by the time of graduation. These relate to the skills, knowledge, and behaviour that students acquire through the programme."
>
> (EAC, 2017)

iv. Performance Criteria and Performance Indicators

The performance criteria are defined as a set of measurable statements which define the learning outcome. They identify the specific knowledge, skills, attitudes, and/or behaviour which students must demonstrate in order to achieve the outcome (Gurocak, 2009). Likewise, IEA (2011b) defined performance indicators as the assessable actions that a person must demonstrate in order to satisfy an outcome (IEA, 2011b). These terms, performance criteria and performance indicators defined by Gurocak (2009) and IEA (2011b) as follows are largely the same. This research will apply the term as proposed by Gurocak (2009).

v. Continuous Quality Improvement (CQI)

Continuous quality improvement (CQI) is the systematic process of identifying, describing, and analysing strengths and problems and then testing, implementing, learning from, and revising solutions. (ABET, 2017a) defined CQI process of an engineering programme as "the programme must use appropriate, documented processes for assessing and evaluating the extent to which the student outcomes are being attained. The results of these evaluations must be systematically utilised as input for the continuous improvement of the programme. Other available information (i.e., feedback from stakeholders) may also be used to assist in the continuous improvement of the programme."

vi. Assessment

> "Assessment is one or more processes that identify, collect, and prepare data to evaluate the attainment of student outcomes. Effective assessment uses relevant direct, indirect, quantitative and qualitative measures as appropriate to the outcome being measured. Appropriate sampling methods may be used as part of an assessment process."
>
> (ABET, 2017a).

vii. Assessment Model

Assessment model is the approach taken to determine the performance or attainment of programme outcomes by students in a programme. The model adopted by the HLIs to deliver, assess and evaluate the achievement of programme outcomes (EAC, 2017).

1.12 Summary

This chapter started by establishing the research background. It highlighted Malaysia's entry to the Washington Accord and the importance of programme outcomes assessment as a result of the entry, the challenges faced by HLIs in assessing programme outcomes, and the call for a sustainable framework to produce graduate engineers with the ability to solve present and future engineering problems. It was then followed by formation of research questions and objectives. Based upon some theories underpinning the research, the research frameworks (conceptual and theoretical) were established. Significance of the research, scope of the research, and some important definitions used in this research were presented here, in this chapter.

This thesis is divided into five chapters. Chapter 1 is the present chapter which provides the general introduction to the research. Chapter 2 will review the literature related to the research, i.e., the theoretical foundations, the characteristics of each EAC’s programme outcome, types of assessment model and course for assessing programme outcomes, research gaps and systematic review of literature. Chapter 3 details the methodology of the research. It covers the methods and instruments used to achieve the required results. Chapter 4 contains data analysis and discusses all qualitative data used in producing results. Chapter 5 discusses the results obtained from the analysis according to the findings in Chapter 4 and forwards the conclusion of the research. It highlights the implications, recommendations and limitations of the research and ends with suggestions for possible further research.

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