Sustainable Assessment: The Inevitable Future of Engineering Curriculum

Article history
Received
7 February 2022
Received in revised form
3 May 2022
Accepted
19 June 2022
Published online
30 June 2022

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Abstract
The programme outcomes, also known as graduate attributes in the International Engineering Alliance, serve as a benchmark of standards for engineering education to higher learning institutions in Malaysia and other signatory countries under the educational accords. Various studies conducted around the world have revealed that evaluating programme outcomes is perhaps the most important criterion for Outcomes-Based Education (OBE) which focuses on improving graduates' intellectual skills and capabilities. Several Higher Learning Institutions (HLIs) in Malaysia have struggled with assessing programme outcomes since the Engineering Accreditation Council Malaysia (EAC) introduced OBE in 2005. Despite the fact that the programme has been in place for over a decade, issues with assessing programme outcomes persist. Unsustainable effort and meaningless outcome assessment among academic staff are exacerbated by a lack of a specific programme outcome model, improper use of assessment tools, and the collection of massive amounts of unnecessary data. The challenges of assessing programme outcomes experienced by HLIs and academic staff are elaborated on in this article. The concept of sustainable development is introduced, which is believed to be capable of alleviating the problems associated with programme outcome assessment. The background of the adoption of OBE in Malaysia, as well as the assessment requirements of the Washington Accord, are presented in order to emphasise sustainable assessment as the inevitable future of engineering curriculum. The sustainable assessment in engineering curriculum advocated in this article aims to produce sustainable engineering graduates while also reducing the burden of programme outcomes assessment on academic staff.

Keywords: Programme outcome; Engineering accreditation; Outcomes-based education; Sustainable assessment.

1. The Washington Accord and Outcomes-Based Education (OBE)

The Washington Accord is an agreement between the accreditation bodies responsible for accreditation or recognition of undergraduate engineering degree programmes in its signatory countries. The accord is a multi-lateral agreement between bodies responsible for accreditation or recognition of tertiary-level engineering qualifications within their jurisdictions that have decided to work collectively to assist the mobility of professional engineers (IEA, 2022). The Accord has grown from its six founding signatories in 1989 to a well-sought-after organisation with 21 signatories as of 2022 with Costa Rica being the most recent addition (IEA, 2022). After serving as a provisional member since 2003, the Board of Engineers Malaysia (BEM) was admitted as a full signatory of the Washington Accord for Malaysia in June 2009. It was the 13th signatory of the accord. 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 as having met the academic requirements for entry into the practise of engineering by the other signatory countries (Liew et al., 2014; IEA, 2011). Malaysia's entry into the Accord was a significant milestone in the country's engineering education whereby its graduates are recognised and met the academic standards for engineering practice in other signatory countries. The engineering degree programmes in Malaysia are accredited by the EAC, a body delegated by BEM.

Although every signatory countries may have a distinct set of assessment criteria in their accreditation programme standards, one of the goals of the Washington Accord is to place a greater emphasis on the programme outcomes assessment (IEA, 2011). The list of programme outcomes was agreed upon by all signatory countries for the purpose of benchmarking engineering education standards and serves as an example of the outcomes expected of graduates from a Washington Accord signatory country's accredited programme (IEA, 2021). In 2012, the EAC adopted the same set of programme outcomes for the accreditation of engineering programmes in Malaysia. According to EAC (2020), engineering programmes must establish a process of measuring, assessing, and evaluating the degree to which students achieve programme outcomes, and the results of this assessment process must be used for continuous improvement. The EAC does not prescribe the details on the assessment process. HLIs must instead demonstrate that they have a robust assessment process in place that allows for continual improvement.

The Accreditation Board for Engineering and Technology, Inc. (ABET) of the United States which was founded in 1932 and has accredited over 2,999 programmes as of October 2021 (ABET, 2020) is highly benchmarked by the Washington Accord signatory countries. It defined assessment with regards to student outcomes as follows:

> "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, 2018)

This definition of assessment by ABET (2018) highlights that the effectiveness of the assessment is determined by the appropriate use of relevant direct, indirect, quantitative, and qualitative measures.

The International Engineering Alliance (IEA) introduced outcome-based accreditation criteria in 2005 through a set of individually assessable outcomes to assist signatories and provisional members establish their accreditation systems (IEA, 2013). The graduation attributes are exemplars of the characteristics required of a graduate from a signatory country's accredited programme, and are equivalent to the twelve programme outcomes outlined in the 2020 EAC programme accreditation standard. According to Spady (1994), Outcomes-Based Education (OBE) is as "an educational system that focuses and organises what is essential for all students to be able to do well at the end of their learning experiences. This means starting with a clear picture of what students should be able to do, then organising curriculum, instruction, and assessment to ensure that this learning happens." Butler (2004) went on to explain that one of the most important aspects of OBE is the learners' commitment to lifelong learning and professional growth. In this context, OBE aims to produce sustainable graduates capable of functioning in a complex society and solving future problems (Liew et al., 2020).

OBE can be seen of as an educational theory or philosophy based on a certain set of beliefs and assumptions about learning, teaching, and the systemic structures within which activities take place (Killen, 2000). Many of these OBE approaches have been documented in the EAC accreditation programme standards, for example, under the criteria of contents and teaching approach, where the mandatory accreditation requirement of an integrated design project in the engineering curriculum encourages students to work in a team to apply classroom knowledge to a real-world situation (EAC, 2020). In essence, OBE requires change within the educational system to facilitate learning for learners to reach the desired outcomes. The focus of education has shifted from the educator to learner with the role of an educator being to enable and support all learners to achieve the desired outcomes. In the meantime, the learners are expected to actively participate and contribute to the learning process, as well as to be devoted to professional development and lifelong learning (Liew, 2019).

2. The Engineering Accreditation Council Malaysia's Programme Outcomes

The programme outcomes, also known as graduate attributes stipulated in the IEA graduate attributes and professional competencies serve as a benchmark of standards for engineering education to HLIs in Malaysia as well as other signatory countries of the Washington Accord (IEA, 2013; EAC, 2020). These programme outcomes are intended to prepare engineering graduates for future technological and societal developments, and help them acquire new knowledge that may be applied to 21st-century problems (IEA, 2013). Understanding these programme outcomes is generally a common challenge among the academic staff, and a lack of understanding has frequently resulted in poor constructive alignment and unsustainable assessment (Liew, 2019). The EAC's programme outcomes are widely available and can be referred from its accreditation programme standard (EAC, 2020). According to Hanrahan (2012), the programme outcomes can be classified into four groups, namely knowledge-oriented, problem-solving skill, skill-oriented, and attitude-oriented. The relationship between competency, programme outcome, and knowledge, skills, and attitude is illustrated in Figure 1.

The Washington Accord's first five programme outcomes (engineering knowledge, problem analysis, design or development of solutions, investigation, and modern tool usage) are seen as the enablers and joint enablers of engineering applications (Liew et al., 2020). Engineering applications are examples of problem-solving that are embodied in the above-mentioned outcomes (Hanrahan, 2012). According to Hu Hanrahan (2009), the programme outcomes on problem analysis and design or development of solutions are related to the analysis of engineering problems and the synthesis and design of solutions, whereas the programme outcome on investigation is related to the investigation of problems and is thus a type of problem-solving as well. He further added that the use of engineering knowledge and the store of methods or tools are both joint enablers of engineering applications. Therefore, the programme outcomes in this category can be categorised as the ability to

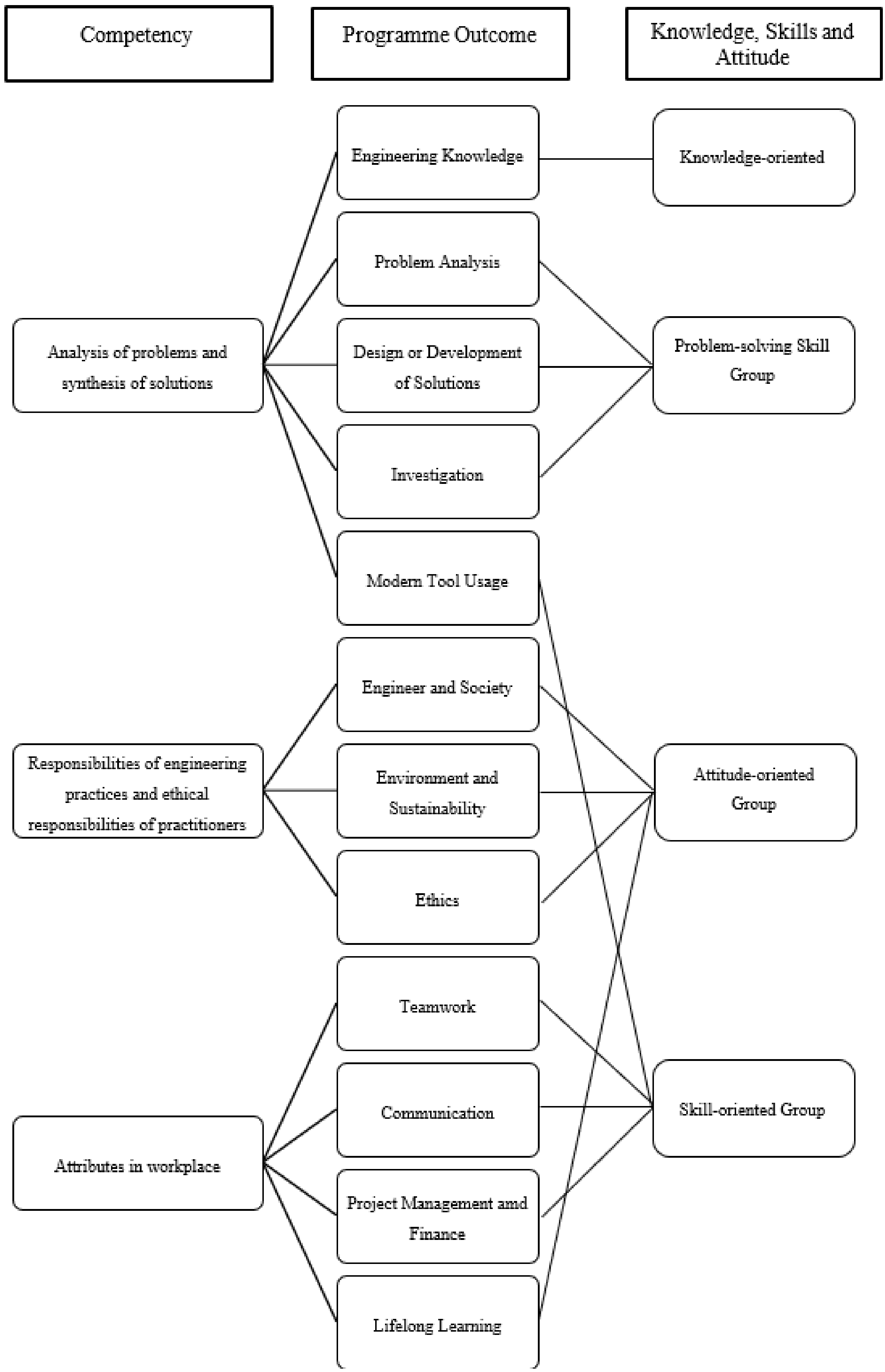

Figure 1. The relationship between competency, programme outcome, and knowledge, skills and attitude (Hanrahan, 2009; Hanrahan 2012; Liew, 2019)

analyse problems and synthesis solutions using engineering knowledge supported by engineering tools and methods.

Graduate engineers have a larger range of responsibilities beyond their technical roles (Hanrahan, 2009). These responsibilities are spelt out in the programme outcomes on engineers and society, environment and sustainability, and ethics. Engineer and Society is concerned with the need of graduate engineers to understand the issues arising from engineering activities, such as social and cultural, health and safety, economic, legal, regulatory, environmental, and sustainability, whereas Environment and Sustainability is concerned with the need for graduate engineers to predict and detect the impact of engineering activity on the environment, as well as to incorporate sustainability considerations into their work. Meanwhile, Ethics is concerned with the need for graduate engineers to understand and to act ethically. In summary, the programme outcomes in this category can be summarised as engineering practise responsibilities in terms of social, economic, cultural, health, safety, regulatory, environmental, and sustainability challenges, as well as engineering practitioners' ethical responsibilities (Hanrahan, 2012). In summary, this category encompasses engineering practise responsibilities in terms of social, economic, cultural, health, safety, regulatory, environmental, and sustainability challenges, as well as engineering practitioners' ethical responsibilities (Hanrahan, 2012).

The final four programme outcomes: teamwork, communication, project management and finance, and life-long learning are individual attributes that are essential in the engineering workplace. Engineering graduates may progress to the management of projects, control of finances and dealing with risk, and supervision of people. They must adapt to the constant change of knowledge, technology, applications, and environment. Graduate engineers must be able to communicate effectively, collaborate with people in other disciplines, continue learning, and deal with the impacts of engineering activity (Hanrahan, 2009).

3. Characteristics of an Effective Programme Assessment Model

Programme outcomes assessment model is the approach taken to determine the attainments of programme outcomes by students. It was recognised that an effective programme outcomes assessment model should use a good combination of direct and indirect assessment tools to assess, analyse and evaluate students' outcomes; the appropriate use of direct, indirect, quantitative, and qualitative measures to the outcome being measured; the model should also practise systematic data collection and able to provide evidence to demonstrate attainment of outcomes with a well-documented process; and finally, it should demonstrate that a continual improvement process is in place (Gurocak, 2009; ABET, 2018).

In the Malaysian context, the EAC programme accreditation standards (EAC, 2020) states that engineering programmes seeking accreditation must design their curriculum around the programme outcomes specified in the programme standards. The programme standards outlined three requirements: the curriculum, teaching-learning activities, and assessment tools must all support the achievement of programme outcomes; programme outcomes must also be assessed and used for continuous quality improvement (CQI); and engineering programmes must demonstrate a high level of stakeholder involvement in the process (Liew, 2021a). Given that, Liew (2021a, 2021b) suggested that the characteristics of an effective programme assessment model shall:

a) Utilise a good combination of direct and indirect assessment tools to assess, analyse and evaluate students' attainment of outcomes;
b) Provide evidence that demonstrates students' attainment of outcomes with a well-documented process;
c) Demonstrate that a continual improvement process is in place;
d) Support the attainment of outcomes with well-aligned curriculum teaching-learning activities and assessment tools;
e) Show a high degree of stakeholders' involvement.

4. Assessment Tools for Programme Outcomes Assessment

In the assessment of programme outcomes, HLIs in Malaysia adopt both direct and indirect assessment tools as illustrated in Figure 2. The appropriateness of these tools for outcome assessment will be discussed in this section.

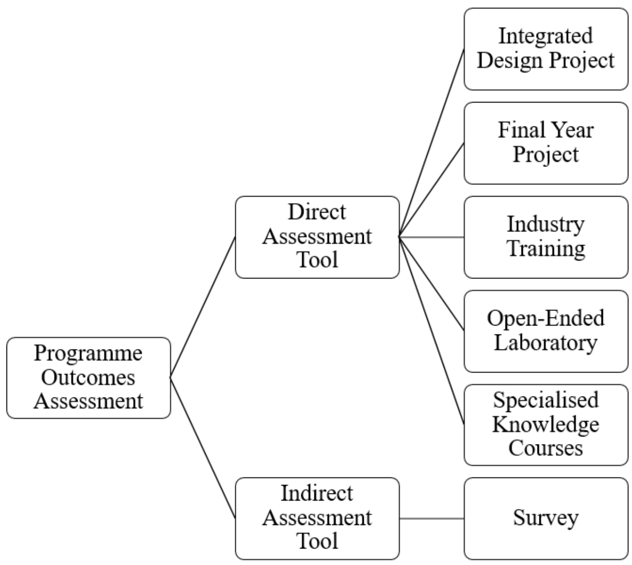

Figure 2. Assessment tools for programme outcomes assessment (Liew, 2019)

Integrated design projects use the principles, concepts, and techniques learned in earlier engineering courses to solve complex engineering problems and design systems, components, or processes. In addition to addressing the project's stated requirements, the impact of the solutions to public health and safety, as well as cultural, societal, economic, and environmental must be considered (EAC, 2020; ABET, 2018). An integrated design course is one of the indicators of outcomes and an ideal milestone for assessing the qualities of the undergraduate engineering experience (Davis et al., 2002; Shaeiwitz, 2002; Daniel et al., 2006; Gnanapragasam, 2007; Liew et al., 2020; EAC, 2020). The design course can assess numerous aspects by measuring technical and communication competencies. In addition, students' ability to solve design problems with realistic constraints can be assessed (EAC, 2020). Typical performance assessment tools include project progress by the course instructor or facilitator, peer review of team member participation, project reports by course instructor or facilitator, and presentation assessment by the public (Scales et al., 1998; Yousafzai et al., 2015; Zytner et al., 2015).

Furthermore, according to IEA (2014), integrated design projects can be used to address some of the characteristics of complex engineering activities. During their undergraduate studies, students are expected to experience some of these characteristics that will help them transition to professional life. These characteristics are common in the industry, incorporating them into the undergraduate engineering curriculum will facilitate students' transition from student communities of practise to professional communities of practise (Lave, 1988; Dym et al., 2005; Johri & Olds, 2011; Hotaling et al., 2012). Johri and Olds (2011) further elaborated that industry-based integrated design projects allow students to apply their skills and knowledge toward developing a robust understanding of what it means to be an engineer.

Final year project, on the other hand, is defined by Jawitz et al. (2002) and Fraile et al. (2010) as an activity carried out by students at the end of an engineering programme. It is regarded as an individual task that a student must do under the supervision of one or more tutors; and it must be sufficiently complex to necessitate the integration of student's knowledge and training acquired throughout his or her studies (Jawitz et al., 2002). It is one of the most effective ways of introducing an investigative research-oriented approach to engineering studies and sourcing of knowledge externally from the real-world (IPENZ, 2017; EAC, 2020). According to Liew et al. (2020), final year project involves the review of open research literature which challenges students to interpret new information, perform critical analysis, generate own ideas and judgments, and learn independently.

EAC (2020) defined industrial training as a key component of learning in an integrated engineering academic curriculum. Industrial training equips students with knowledge base and skills necessary to integrate isolated and abstract concepts into practical applications (Noyes et al., 2011). Furthermore, it allows students to participate in ongoing job experiences, learn from them, and reflect on them (Raelin et al., 2014). It helps students' transition into full-time employment and assists them in overcoming the challenges associated with first-job experiences. However, in Malaysia, the primary goal of industrial training is to gain an understanding of engineering practise rather than to acquire craft skills (Liew et al., 2020). Similar to the integrated design project, industry training can address some of the attributes of complex engineering activities (IEA, 2014). Students are expected to develop some of these attributes during their undergraduate studies that will them transition to professional life.

In addition, an open-ended laboratory is another direct assessment tool in assessing programme outcomes. Open-ended assessment is considered as a strength of curriculum in engineering education, owing to its ability to challenge students at the required depth involving high-level critical thinking (EAC, 2015). This approach is appropriate for engineering education because it produces self-directed, reflective engineering graduates who can integrate knowledge, think critically, practise life-long learning and collaborative with others (McKinnon, 1999). In the open-ended approach, the problem may have multiple solutions, and there is no obvious solution. The main goal of an open-ended laboratory is to encourage students to design their experiments related to the topics of study. This encourages students to do self-reflection and, as a result, develop their experimental approaches. Students are expected to plan out their approaches to laboratory activities.

Engineering specialist knowledge courses are those that can demonstrate the attainment of programme outcomes (Yamayee & Albright, 2008). According to Hordern (2014), engineering specialist knowledge is built upon engineering fundamentals which are built on natural sciences, with mathematics serving as an essential facilitator for these layers of knowledge. With this definition, natural science courses, mathematics courses, and some engineering fundamental courses are not ideal for demonstrating programme outcomes, although they are important in the formation process of an engineering graduate's knowledge profile. By definition, the demonstration of programme outcomes is typically shown at the end of the programme (ABET, 2018; EAC, 2020), therefore, engineering specialist knowledge courses are well-suited for this purpose.

Surveys are commonly used as indirect assessment techniques to obtain data that cannot be observed (Soundarajan, 2002; Olds et al., 2005). Some possible survey assessment tools at the programme level include graduating exit survey, alumni survey, and employer survey (Felder and Brent, 2003). Graduating exit surveys are mostly used for triangulation with direct assessment, whereas alumni surveys are primarily utilised to evaluate programme objectives. Despite the fact that surveys are the most widely utilised assessment tool, they must be used with caution due to possible flaws in their design (Soundarajan, 2002). Because they are self-report instruments, the accuracy of the information acquired is determined by the extent to which participants choose to respond honestly and the researchers' ability to report accurately (Olds et al., 2005). Hence surveys are subjective, and over-reliance on them may be misleading (Barbero et al., 2004). Liew (2019) suggested that they should be used in tandem to triangulate the data collected from direct assessment tools.

5. The Challenges of Assessing Programme Outcomes

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 (ABEEK, 2015; ABET, 2018; CEAB, 2019; ECSA, 2019; EAC, 2020). It is the sole responsibility of the HLIs to develop and establish suitable and appropriate outcome measures for their programmes. 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, 2019).

A number of amendments were made to the EAC's accreditation programme standards as Malaysia moved closer to being a full member of the Washington Accord. In 2008 and 2010, the Malaysian Council of Engineering Deans and the EAC held multiple meetings to discuss issues relating to accreditation (EAC, 2010). The engineering deans were concerned that the accreditation programme standards presented unclear requirements for engineering programmes accreditation. They also emphasised the burdensome responsibilities and massive amount of data preparation and collection that accreditation necessitates, according to Liew et al. (2021a). Apart from that, he highlighted that the HLIs' OBE or programme outcomes assessment models were unable to reflect the true outcomes of their students during the engineering programme accreditation exercises in Malaysia. The models have underlying issues such as poor constructive alignment, improper use of assessment tools for different types of outcomes, and failure to use assessment data to improve the programmes.

A comparison with the global scenario was performed in order to identify the gravity of the issue. Literature indicated that the challenges of assessing programme outcomes at the institutional level have been reported as early as the 1990s. Although ABET places a strong emphasis on programme objectives and programme outcomes, many HLIs in the United States misinterpreted the assessment and evaluation requirements due to a lack of understanding of 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.

6. Sustainable Assessment

The concept of "sustainable development" was originated 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) then established the concept of sustainable assessment based on a reframed definition of sustainable development that 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 is commensurate with the programme outcomes defined by the IEA and EAC that require engineering graduates to solve complex problems and function in a complex society (IEA, 2013; EAC, 2015). In another word, this concept emphasises on the importance of assessment practices to equip students for the challenges of learning and practice that they will face in the workplaces once their current episode of learning at the HLIs is completed (Boud & Soler, 2016).

According to Beck et al. (2011), educational sustainability can be defined as a feature of educational systems that involves not only the physical environment but also the sustainability of educational practices (Beck et al., 2011). In addition to the sustainable assessment of educational practices stated earlier, the sustainability of academic staff's efforts must be addressed when establishing a framework for assessing programme outcomes. According to Fullan (2007), academic staff and students sustain each other's learning processes in sustainable education. He emphasised that the key to sustainable educational systems is to put academic staff and students at the forefront of driving force. What has been learned continuously stimulates one's own and others' new learning, as well as the desire to continue learning. As a result, institutions transform into learning communities that eagerly exploit the huge potential of social interaction to keep the energy flowing (Van den Branden, 2012). In this approach, learning energy is converted into renewable energy.

Sustainable assessment theory is an emerging approach to assessment that complements the existing summative and formative assessment methods in the context of programme outcomes assessment (Boud 2000; Boud & Falchikov, 2006). The objective is to integrate assessment with teaching and learning so that graduates can evaluate their learning abilities in a variety of non-academic, relatively complex settings after graduation (Beck et al., 2011). As a result, Beck et al. (2011) concluded that long-term assessment is part of the 'constructive alignment' advocated by Biggs between teaching and learning and assessment tasks (Biggs, 2003). The missing link in Biggs' constructive alignment model is that present assessment practices in higher education do not adequately prepare students for a lifetime of learning and the assessment challenges they would face in the future (Boud & Falchikov, 2006). According to Boud (2000) and Boud and Falchikov (2006), sustainable assessment theory encompasses four principles: (1) a 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) the development of devices for self-monitoring and judging progress toward goals.

The complex engineering problems defined by the IEA are identical to the nature of the problems that arose in the industry (Liew et al., 2020). From that standpoint, EAC's programme outcomes embrace the nature of the problems which engineering students must be trained 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 apply 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. The challenge with 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 example, 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 the 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; Hamzah & Liew, 2018), resistance from academic staff (Gurocak, 2009), and lack of a culture of assessment among academic staff (Anagnos et al., 2008; Briedis, 2013). These issues can be summarised under Biggs' (1995) three main factors that hinder the change in assessment among the academic staff and are closely related to the sustainability of academic staff's efforts highlighted by Fullan (2007) and Van den Branden (2012).

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 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).

To summarise, the concept of sustainable assessment necessitates the alignment of all assessment practices with teaching and learning in order to allow learners to actively participate and contribute to the learning process, as well as to prepare them for the challenges of learning and practice that they will face in the workplace once their current episode of learning at the HLIs is completed (Boud, 2000; Boud & Falchikov, 2006). The concept of sustainable education described by Fullan (2007) and Van den Branden (2012) is also adopted to achieve sustainability in terms of academic staff efforts, reducing the feeling of burden due to assessment. The relationship between sustainable assessment and the major elements of engineering curriculum is illustrated in Figure 3.

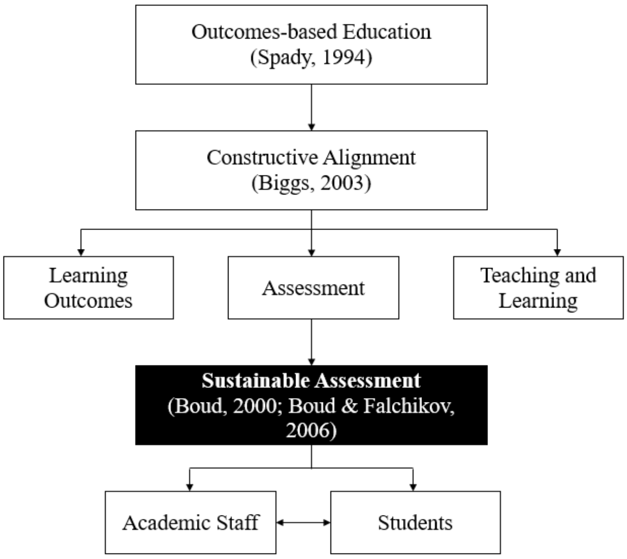

Figure 3. Sustainable assessment to complement the constructive alignment advocated by Biggs (2003) in engineering curriculum

The first two principles of sustainable assessment are concerned with the establishment of assessment standards and criteria at the faculty and institutional levels, which should be capable of alleviating academic staff's problems with programme outcome assessment. The following two principles address student-academic staff collaboration and students' self-monitoring of their own progress toward stated goals, both of which are not widely practiced in Malaysia or other Washington Accord signatories. This is regarded as a practice gap (Figure 4) that HLIs must address in order to ensure that engineering programmes produce sustainable engineering graduates who are prepared for future technological and societal changes, and that the assessment model and practices used are sustainable in terms of effort, thereby reducing the burden of programme outcome assessment on academic staff.

7. Conclusion

Most HLIs conduct programme outcomes assessments to gain accreditation for their programmes, not to improve the quality of their graduates. Most HLIs' programme outcomes assessment is currently done on an ad hoc basis, which is done whenever accreditation is required. As a result, the challenge is to move from a system designed for accreditation to one that produces sustainable engineering graduates. Courses should be constructively aligned to the assessment, teaching and learning, and course outcomes, and the intended programme outcomes. An effective assessment model should encourage the use of performance criteria for programme outcomes, which will result in sustainable effort from academic staff. The first two principles of sustainable assessment could address issues with programme outcome assessment, whereas the following two principles, which are not widely practiced, address student-academic staff collaboration and students' self-monitoring of their own progress toward stated goals. This is an area worth investigating in the future because the success of an engineering curriculum necessitates a sustainable programme outcomes assessment that not only aims to produce sustainable engineering graduates who are prepared for future technological and societal changes and who can acquire new knowledge and apply it to new problems, but also to be sustainable in terms of effort, reducing the burden of programme outcomes assessment on academic staff.

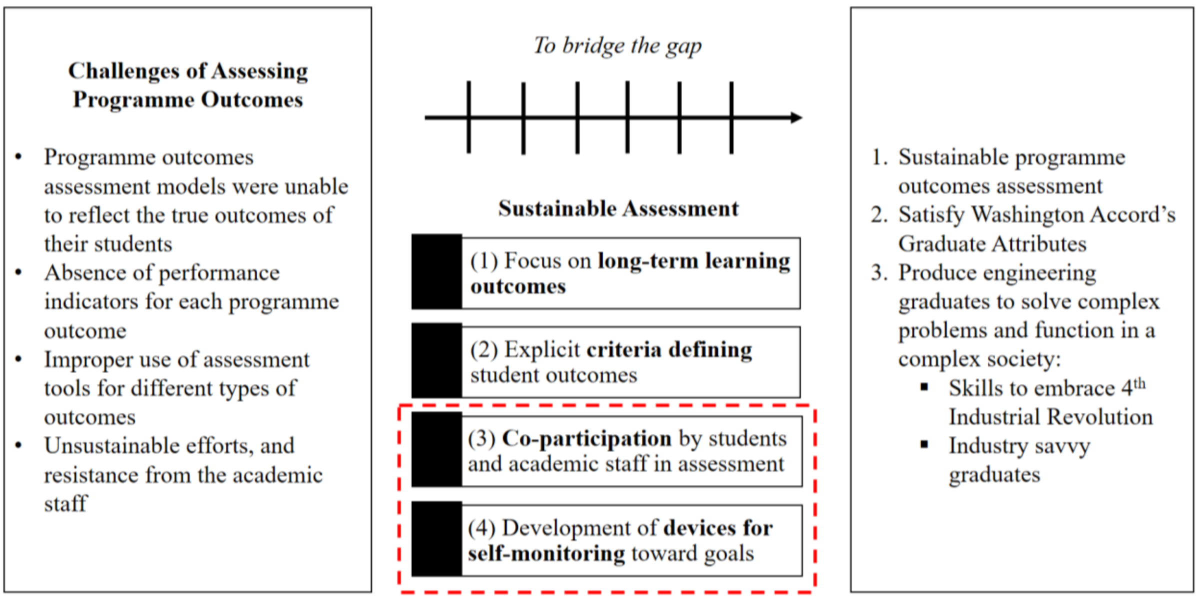

Figure 4. Illustration of incorporating the concept of sustainable assessment to address the current challenges of assessing programme outcomes (principles that are not commonly practiced are indicated in red box)

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