

SUSTAINABILITY INTEGRATION INTO ENGINEERING CURRICULA: A CHOICE BETWEEN 'STAND-ALONE' OR 'INTERTWINED'

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ABSTRACT

In view of the mounting evidence on the destruction of environmental quality and loss of cultural heritage as a result of technology development, various organizations have seen the dire need for sustainable development which can be acquired through education on sustainability. In institutions of higher education, engineering is one of the programmes that are active in seeking to integrate sustainability into its curricula. Several researchers have conducted researches on means of incorporating sustainability into engineering curricula and such means can generally be categorized into the horizontal or vertical approach. An integration approach is considered horizontal when the sustainability or environmental component is intertwined into the existing courses. On the other hand, integration through a specialized or stand-alone course on sustainability is considered as vertical approach. Both of these approaches are used and there is no consensus on which approach works the best. The existing literature has shown evidence on engagement of these two approaches by the American, European and Australian Institutions of Higher Education. However, to the best of the authors' knowledge, there has not been any similar study for the Malaysian IHE. Therefore, this research was conducted to identify the current sustainability integration approach for 3 traditional engineering disciplines, namely Civil, Mechanical and Electrical Engineering in 5 Malaysian IHE. An analysis of the engineering syllabi was conducted to identify if horizontal or vertical approach is used by the selected IHE for these 3 engineering disciplines. The result showed that horizontal approach was more commonly employed compared to vertical approach. This finding concoced with opinion of some of the researchers that sustainability education through horizontal approach may be more suitable for engineering programme which encourages interdisciplinary learning.

Keywords: sustainability, engineering, curricula, integration, horizontal, vertical

1. INTRODUCTION

Sustainable development (SD) is defined as development that meets the current needs without compromising the ability of the future generation to fulfill their own needs (World Commission on Environment and Development (WCED), 1987). In literature, the term 'SD', is commonly used interchangeably with the term 'sustainability' in literature (Mitchell, 2000). Sustainability is understood as a development that does not lead to diminished quality of life (Mihelcic et al., 2003). Both of these terms carry the same underpinning elements, which are environment, economy and society. Despite the similar underlying meanings of these two terms, it is generally understood that SD is a tool used to achieve sustainability (Mitchell, 2000)

In response to the overwhelming figures on environmental and societal issues, sustainable development has emerged as a term that has gained vast attention from various private and governmental organizations. It is widely believed that education is the main means for cultivating knowledge on sustainability (Abdul-Wahab et al., 2003). UNESCO, (2012) actually highlights the importance of all three levels of education – primary, secondary and tertiary for sustainable development. As stated in the policy of Education for Sustainable Development by UNESCO(2012), education makes sure that proper natural resources management, ecological sustainability and sustainable living practice are in place to pave the roads towards sustainable development. The role of education in shaping a sustainable society is thus undeniable.

A wide array of studies have been conducted on how sustainability can be integrated into the tertiary education system and those studies are mainly constructed on the case studies in American, European and Australian IHE. These approaches can generally be categorized into horizontal and vertical approach. This paper aims at studying the approaches adopted by the Malaysian IHE for sustainability education based on the integration approach in engineering disciplines.

2. LITARATURE REVIEW

2.1 Roles of Institutions of Higher Education for sustainability education

The roles of Institutions of Higher Education (IHE) are not replaceable when it comes to tertiary education. The skill and knowledge the students gain in IHE are what they apply in the workplace (Segalàs et al., 2009). IHE plays the operational and advocacy roles in delivering the knowledge on sustainability (Carew & Mitchell, 2006). In view of such critical roles, various world declarations on tertiary education for sustainability, membered by a collective of more than 1000 IHE worldwide, have emerged(Corcoran et al., 2004). The most commonly discussed declarations include Tailloires Declaration 1990, Halifax Declaration, 1991, Rio Declaration 1992, Swansea Declaration 1993, Kyoto Declaration 1993 and etc. All of these declarations have highlighted the roles of IHE in addressing sustainability education with outlines, principles or guides on how to embed sustainability into IHE and the tertiary education system. As a result, some vigorous efforts in integrating sustainability into the campus and their curriculum have been observed. To name a few, Delft University of Technology started integrating sustainability into its engineering curriculum in 1998 (Quist et al., 2006)and Georgia Institute of Technology created a course related to sustainability for its engineering programme in 1999 (Watson et al.,

2013). Some Asian IHE, such as those in Taiwan and Japan, have also made substantial effort in integrating sustainability into tertiary education. In fact, there is a rising number of IHE that commit to sustainability education (Watson et al., 2013). Many IHE have also concreted policies and action plans as institutional guide in order to make sustainability education more efficient. Among all, the North American, European and Australian IHE are among those that have established experience in promoting sustainability integration into IHE.

2.2 Capacity building towards sustainability and the engineering discipline

As mentioned earlier, sustainability education at tertiary level is inevitable. While every profession is responsible towards shaping a sustainable future for the living beings, engineering discipline is among the most active in contributing to capacity building towards sustainability and considered as pioneer in this effort by some of the researchers (Fenner et al., 2012). It has long been realized that engineering education which aims at producing engineers that provide technical solutions to meet the societal demands should be oriented towards sustainability so that the future engineers are able to address the balance between economic, environmental and societal development (Brown & Elms, 2013; De Graaff & Ravesteijn, 2001; EESD, 2010). Numerous researches have also suggested that engineers need to be trained on sustainability in order to meet the developmental needs, environmental needs, societal needs and employers needs (Goldman et al., 2013; Miller, 2014; Pritchard & Baillie, 2006). Therefore, it is not surprising that integration of sustainability into engineering curriculum is a must on the path towards a sustainable future.

2.3 Integration of sustainability into engineering programme

Based on the literature, there are generally 4 approaches that are used for sustainability integration into education which are i) some coverage of environmental issues in the existing courses (Lozano, 2010; Mulder, 2006; Mulde; Thomas, 2004); ii) a specific course on sustainability (Cortese, 2003; Kumar et al., 2005; Mulder et al., 2005); iii) intertwining sustainability into the existing regular courses (Abdul-Wahab et al., 2003; Crofton, 2000; Kamp, 2006; Peet et al., 2004) and iv) graduate specialization course on sustainability (Crofton, 2000; Kamp, 2006; Kumar et al., 2005; Mulder, 2006). These four approaches can be further categorized as horizontal or vertical approach, as suggested by (Cuelemans & de Prins, 2010). An integration is considered horizontal when the sustainability components are intertwined into the existing courses while an integration is considered vertical when the sustainability-specific courses are separated as individual courses within the curricula (Cuelemans & de Prins, 2010). Based on the definition, it can be suggested that (i) and (iii) are horizontal approaches and (ii) and (iv) are vertical approaches. The categorization is summarized in Table 1.

Table 1 Sustainability integration approach

Vertical approach	<ul style="list-style-type: none">- Specific course on sustainability- Graduate specialization course on sustainability
Horizontal approach	<ul style="list-style-type: none">- Intertwining of sustainability into the existing regular courses- Some coverage of environmental issues in the existing courses 1

Vertical approach is a common approach that is normally used at the initial stage of integrating sustainability into curriculum (Haigh, 2005). It is deemed effective in delivering the fundamental concepts and knowledge related to sustainability (Peet et al., 2004) and a more in-depth knowledge on sustainability can be conveyed through this approach (Morris et al., 2007). This approach has been adopted by some organizations such as the United Kingdom Sustainable Development Education Panel (SDEP) (Azapagic et al., 2005). The disadvantage of this approach, as pointed by Peet et al.(2004) is the students may fail to relate sustainability with their core disciplines, rendering the sustainability education ineffective.

Horizontal approach, on the other hand, is believed to be able to help students understand the link between sustainability and their profession, helping them to blend in sustainability concept into their daily practice (Peet et al., 2004). Cuelemans & de Prins (2010)suggested that this method is more interdisciplinary and therefore preferred for engineering discipline. University of Bath, UK is one of the IHE that has engaged this approach by intertwining sustainability knowledge into the existing courses (Orr et al., 2014) The shortfall of this approach may lie within its possible insufficiency in delivering holistic sustainability knowledge through existing courses which are already compact with other traditional knowledge (Haigh, 2005).

Till-date, there is no consensus on which approach works the best. (Perdan, S., Azapagic, 2000) suggested that as long as an approach is able to cultivate the sustainability knowledge among the students, it is considered appropriate. Based on the literature, most of the relevant studies are based on the case studies in America, Australia and Europe, which have reported that both horizontal and vertical approaches are used in those parts of the world. However, the development of the relevant researches for Asian IHE, including Malaysian IHE is very limited (Ryan et al., 2010). It is therefore worth studying if the Malaysian IHE adopts horizontal or vertical approach in integrating sustainability into its engineering curricula. Does this nation follow the suggestion by Cuelemans & de Prins (2010) which boasts horizontal approach over vertical approach or heed the suggestion by SDEP which promotes vertical approach.

3. METHODOLOGY

This study focused on only three engineering disciplines, which were civil, mechanical, and electrical engineering. The course outlines of the respective engineering disciplines were collected from 5 IHE, anonymously known as A, B, C, D and E. These IHE were selected as they had the longest history in offering engineering programmes compared to other IHE in Malaysia with a significant number of engineering students.

Text analysis of the course outlines of the targeted engineering programmes from the respective IHE was conducted. The relevant key terms such as 'green', 'sustainable development', 'ecology', 'environment', 'society' and etc. were identified. Further analysis was conducted to further confirm the context of those key terms expressed in the course outlines. For example, the term 'environment', which is preceded by the word 'working' does not reflect sustainability.

A simple quantification analysis was then carried out to identify courses which were specific on sustainability and other courses in which sustainability components were intertwined. Then, further analysis was conducted to identify the percentage of number of courses covering sustainability by using the model below.

$$\frac{\text{number of courses covering sustainability}}{\text{total number of courses of the engineering programme}} \times 100\%$$

4. RESULTS AND DISCUSSION

The analysis showed that all the targeted IHE adopted horizontal approach in integrating sustainability into the Civil, Mechanical and Electrical engineering curriculum, as shown in Table 2. It should be noted that no data was obtained for the Mechanical Engineering Programme from IHE D as the respective school had declined to participate in the study. For the Civil Engineering Programme, IHE E had the highest number of existing courses within which sustainability component was intertwined. For the Mechanical Engineering Programme, IHE B had the highest number of existing courses within which sustainability component was intertwined. It was obvious that there were not any stand-alone or specialized courses on sustainability for the targeted engineering disciplines at all the selected IHE. As such, it could be interpreted that all the targeted IHE had engaged horizontal approach in integrating sustainability into the respective engineering curricula.

One of the possible reasons was that the IHE might be under pressure to put greater emphasis on traditional engineering knowledge in order to fulfill the requirement of Engineering Accreditation Council (EAC). A minimum of 120 credit hours are required for engineering courses, out of which 80 credit hours must be constituted of courses on engineering science, principles and application. Based on the observation, the remaining credit hours are usually allocated for other university or national-level compulsory courses or other engineering courses which may help enhance students competency in the engineering profession. It might be challenging for the IHE to try adding on a new course on sustainability into the already packed schedule and such addition may also be overwhelming to the students who are already loaded tonnes of learning.

The IHE may also have already acknowledged that the stand-alone subject may not be sufficient in addressing the complexity of the sustainability education and help the students to relate the knowledge to their disciplines. As suggested by Crofton(2000), horizontal approach may address the needs for interdisciplinary teaching suggested for efficient sustainability education.

Figure 1 gives an interesting insight into the percentage of number of courses covering sustainability. It was found that 24% of the courses of the Civil Engineering Programme of IHE E was infused with sustainability components, which was the highest among all. IHE B had 4% of its Mechanical Engineering courses infused with sustainability components and it was the highest compared to other IHE for the same engineering programme. For the Electrical Engineering Programme, IHE C had 2.1% of its Electrical Engineering Courses embedded with sustainability component, which was the highest compared to the others. It was not known if the percentage of integration had an impact on the overall efficiency of sustainability education. Further studies in this context is therefore needed.

Table 2 Number of stand-alone courses and courses intertwined with sustainability

IHE	Number of sustainability related courses					
	Civil		Mechanical		Electrical	
	stand-alone/ specialised	'intert.'*	stand-alone/ specialised	'intert.'*	stand-alone/ specialised	'intert.'*
A	2	7	0	1	0	1
B	2	3	1	5	0	2
C	1	13	0	2	0	2
D	1	24	N/A	N/A	0	13
E	1	13	0	1	0	1

* intert. - Intertwined

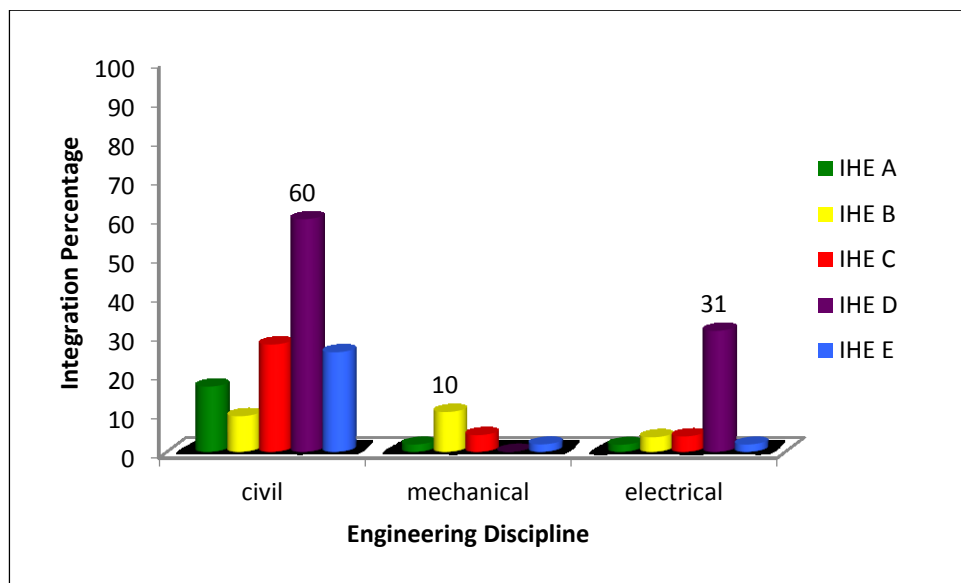


Figure 1 Percentage of number of courses covering sustainability

5. CONCLUSION

Based on the analysis, all of the selected IHE preferred horizontal approach in integrating sustainability into the Civil, Mechanical and Electrical Engineering Programme. None of the IHE engaged vertical approach for electrical engineering, which means that no specialized and specific course on sustainability was offered by these IHE for the respective engineering programme. It is not known which approach is more effective in delivering the sustainability education compared to the other. It is also not known if the integration percentage has a direct relationship with the efficiency of the education. Therefore, further studies are recommended to evaluate the effectiveness of these two approaches through accessing the students knowledge and interest level on sustainability.

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