

UNDERSTANDING OF THE CONCEPT OF SUSTAINABILITY VIA SHORT WRITTEN ASSIGNMENT IN THERMODYNAMICS 1

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ABSTRACT

The subject of Thermodynamics is important for undergraduate students taking the engineering degree, in particular mechanical engineering. It has become the core subject for junior undergraduate engineering students in all universities offering the Mechanical Engineering programme. The subject deals with the fundamental and principle of the energy conservation and emphasizes on the foundation of the thermal science and its related concepts. With the current energy scenario in the world, together with an alarming situation related to environmental issues, young engineers are expected to be sensible in balancing future development and various environmental concerns. Thus many institutions have embarked on the introduction of the sustainability concept to graduating engineers. Different methods were introduced in order to ensure that graduating engineers are well-equipped with the knowledge and understanding of sustainability related issues. One method is to slowly integrates the concept during the early years in the engineering program. This paper describes the investigation of the effectiveness of such introduction of the sustainability concept through one of the most important subject in earlier years of engineering program. In this subject, the concept of sustainability is introduced through lectures, tutorials and assignment. In general, the assessments were distributed through written mode such as tutorial assignment, homework assignment, midterm examination and final examination.

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1. INTRODUCTION

Sustainable development is one of the most important aspects that need to be taken into consideration in the world of engineering where critical elements such as social, economic and environmental are carefully integrated. This is crucial to reduce global imbalance and at the same time enhancing the needs of present and future generations. The past decade has witnessed international interesting incorporation of the skills, attitudes and concepts of sustainability into undergraduate university courses across a wide range of disciplines (Wright, 2002). Awareness of sustainability among young engineer is very important as many of the sustainability issues are related to the engineering discipline. This awareness needs to be applied at early university level to enable good understanding and affection of the concept. In addition, the culminating experience students learned from the junior towards the senior year will further enhanced the understanding of the concept by the time they graduate. The introduction of the sustainability concept at early university year is intended to give an initial exposure on the concept of sustainability. It is envisaged that this understanding will sustain as they progress towards the senior years. Thus, taking into account on the cumulative experience in various teaching and learning activities throughout the university years, it is hoped that graduates are able to master the understanding of the sustainability when they start their working career.

In 2000, Engineers Australia implemented an accreditation process that mandated that academics must ensure that students understand sustainability by the time of graduation (Engineers Australia, 2005). This is one of the efforts made in Australia in implementing sustainability development to graduate students in their country. As the main medium in transferring knowledge and skills to students, lecturer plays an important role to ensure that the engineering graduates are aware of what and how to implement sustainability in engineering professional practice. Various methods can be utilized that includes the introduction of sustainability concept in several courses according to the respected engineering disciplines. This has been comprehensively discussed by Waas et al. (Waas *et al.*, 2010).

Methods to understand sustainability can be considered limitless. There are many other ways to implements sustainability in the context of engineering. For example, Wells conducted course that focusing on design of sustainable plant (Wells, 2002). Lemkowitz et al. explained the characteristics in raising students' moral and intellectual criticality towards to sustainability development (Lemkowitz *et al.*, 2002). Tilbury et al. elaborated that awareness of sustainability is a fundamental element to implement the concept of sustainable development in higher education (Tilbury *et al.*, 2005). Velázquez et al. emphasized that the lack of sustainability awareness and knowledge will cause the unsustainable behaviour among students and communities (Velazquez *et al.*, 2006). Based on Dahle and Neumayer, the misunderstanding of the meaning of sustainable development can affect the environmental interest among students and intensive costs associated with implementing green initiatives could incur (Dahle and Neumayer, 2001).

In line with the vision of the Universiti Tenaga Nasional (A leading global energy university that shapes a sustainable future) the graduates of the university are expected to have good understanding on the concept of sustainability upon graduation. Thus, in order to ensure that

graduates are well-versed with the concept, elements of sustainability were introduced into selected courses at different levels starting from junior undergraduate to senior years. One of the most effective efforts is to introduce specific course in sustainability, called Sustainability Engineering which is taught during the final year of the bachelor program. However, it is thought that the effectiveness towards understanding of sustainability can be further enhanced by introducing the awareness of the concept during the junior level. Thus, the element of sustainability was made compulsory in selected courses which spread over different level of study. In this case, simple task was given to students in compulsory course, Thermodynamics 1 which is taught to second year, first semester students. The element of sustainability is most suited to be integrated in this Thermodynamics 1 course due to the nature of the course itself which emphasize the study of energy. With the analysis of energy, the concept of sustainability could be easily integrated in any chapters within the course.

This paper presents the study on the effectiveness of the introduction of the concept of sustainability in Thermodynamics 1 subject. In this course, the assessment on the element of sustainability is done through written assignment on a given topic. The analysis of the effectiveness of understanding sustainability is done based on students' performance in the assignments, tests and also final examination.

2. ASSESSMENTS METHODOLOGY

In Universiti Tenaga Nasional (UNITEN), the mechanical and electrical engineering students are required to take Thermodynamics 1 in the first or second year of their bachelor program. In this subject, students are introduced with the study of energy that include, conservation of mass and energy, first and second law of thermodynamics, steam power cycle and refrigeration cycle. It was found that the concept of sustainability engineering could be easily integrated into Thermodynamics 1 due to the nature of the subject which deals with energy-related processes. Thus, a wide variety of energy-related processes could be tailored to the applications of sustainability simply by using the concept of minimum loss and impact to the surrounding environment.

In the last few semesters, a new approach was implemented to instill the concept of sustainability to the students. This is done by assigning 'information-searching' concept of assignment as part of the assessment in Thermodynamics 1. The main objective of the assignment is to instill the concept of sustainability to the student by assigning 'scenario based' questions to where student is required to answer by searching information from variety of sources.

The sustainability assignment contributes 5% of the overall mark distribution in Thermodynamics 1 course. The weightage needs to be carefully moderated so that it is sufficient to instill the awareness of sustainability to students and at the same time it must be ensured that the introduction of this assignment does not significantly affect the main objective of the course. For this reason students is advise not to spend more than 2 weeks to complete the work. An example of the question given in Semester 2 12/13 is shown in Figure 1.

Figure-1. Example of Sustainability Assignment

'Sustainable development' can be defined as development that meets the needs of the present generation without compromising the ability of the future generations to meet their needs.

Malaysia is one of the largest producers of palm oil in the world. The palm oil industry is a primary agricultural for our economy. In the industrial process of converting the harvested oil palm fruit into crude palm oil, large amount of water is consumed by palm oil mill. Subsequently, the consumed water would turn into palm oil mill effluent which is basically waste water. Do a research on Palm Oil Mill Effluent and discuss how it can be made to contribute to a sustainable future for Malaysia.

Consider the following:

- How does the mill effluent affect the environment?
- What are green house effect and its potential long term consequence to environment?
- What are the existing legislature, framework and policy available to promote sustainable usage of water, waste water and conservation of environment?
- What are the options available to mitigate the effects of the mill effluent to the environment?
- What are way forward for sustainability?

A rough guide of the format of the report and the marks is as below:

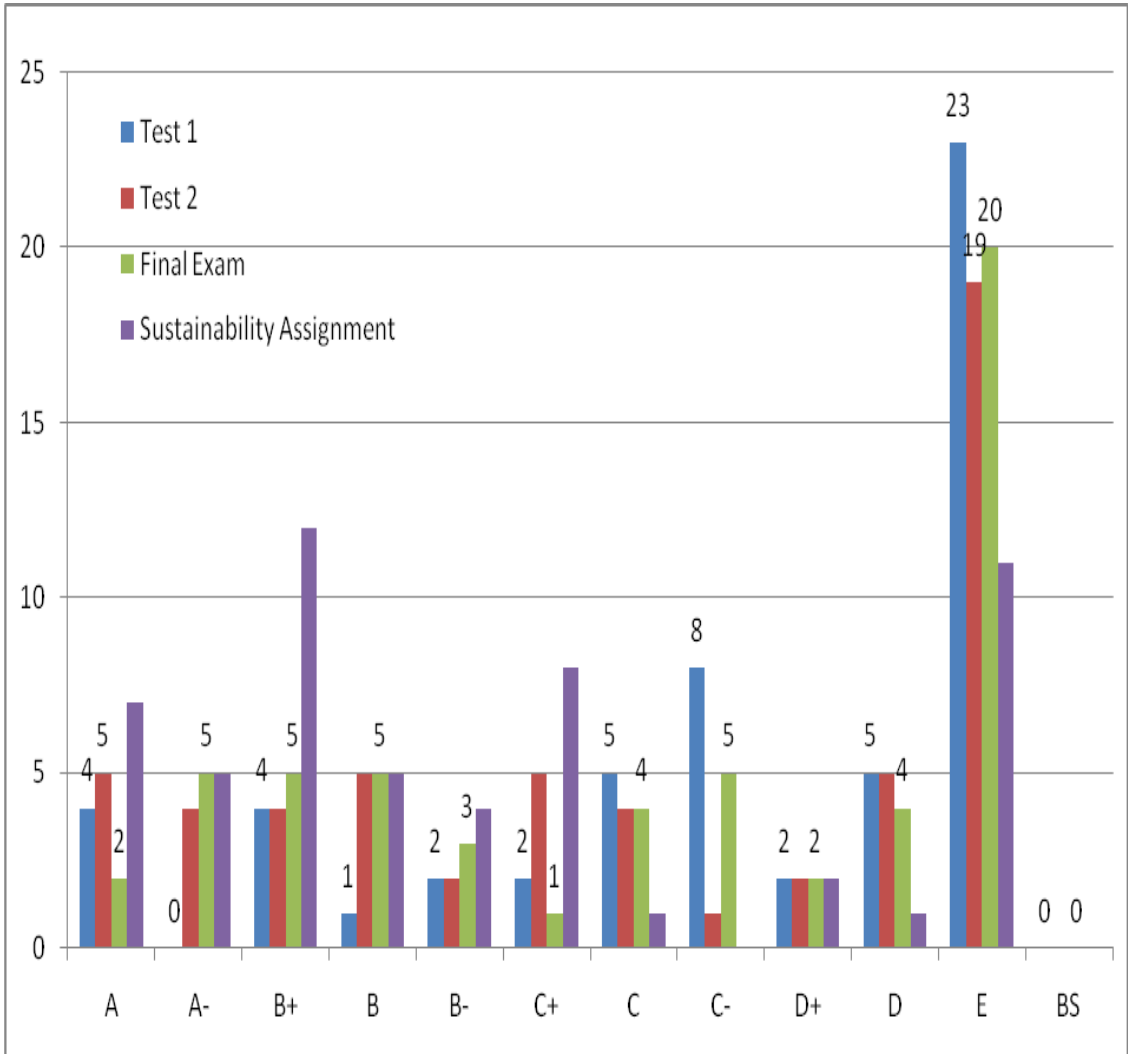
1. Introduction	: 3 marks
2. Research findings/technical info about topic	: 5 marks
3. Discussions/Opinions	: 5 marks
4. Concluding remarks	: 3 marks
5. References	: 2 marks
6. Language	: 2 marks

3. RESULTS AND DISCUSSIONS

3.1. Comparison of Grade Distribution for Different Assessments

The grade distribution for different assessment of Thermodynamics 1 is presented in Figure 2. It shows that most of the students are able to set good result in sustainability assignment compared to other assessments. It is clear that most of the students are able to understand the concept of sustainability through the written assignment that has been given. The assignment question is designed to encourage students to do open literature searching which indirectly will encourage learning on the topic of sustainability. The information obtained from various sources need to be carefully churned out by the students and filtered for unnecessary information to be included in the report. As the students undergo the process, the awareness and understanding of the concept of sustainability will be gained, at least by the minimum understanding. Comparing with other assessments, students are given ample time to carry out the information-searching on the topic given. In this case, the students are given 2 weeks to complete the assignment. Moreover, sustainability is one of the topics that can be considered easy to understand (use of common sense) if the students are diligent to learn about it. Despite having many students getting good marks, there were a few students who failed in the assessment. These students failed the assessment not because of their inability to understand the sustainability but the failure to submit their work.

Figure-2. Grade Distribution for Different Assessment



3.2. Comparison of Grade Distribution for Sustainability Assignment and Final Grade

Figure 3 presents the grade distribution for sustainability assignment and final grade of the student. It is shown that many of the students obtain reasonably good mark in sustainability assignment compared to the final grade result. It can be observed that it is not necessary when the students gain high marks in the sustainability assignment, they also will obtain high marks for final grade. This is due to small contribution of sustainability assessment towards the final grade since the assignment just contributes 5% to the carry mark for final grading. This indicates that sustainability assignment did not give significant effect to the final grade based on current weightage distribution. It is good in future to increase the weightage of the sustainability assignment towards the final grade in order to raise the interest and awareness among the students on sustainability development.

3.3. Comparison of Sustainability Assignment Grade Distribution in Different Sections

Large class size was divided into several sections. Ideally, each section consists of the maximum of 60 students to ensure good teaching and learning environment. For courses which consist of more than one section, ideally, they are taught by the same lecturer to ensure consistency. However, when the class size is very large, different lecturers have to teach different sections. Due to different approaches of teaching and different entry level for different section, it is difficult to determine the factor that influences the performance of students in understanding sustainability for different sections. Figure 4 shows the comparison of grade distribution for sustainability assignment for Section 1 and 2. Both sections are conducted by different lecturer, with different student background. Based on the figure, it is clear that student in Section 2 earned higher marks as compared to the student in Section 1. The difference between the performances shown by the two sections is difficult to determined and needs detail investigations. Nevertheless, the difference could be attributed to different entry background of the students. On top of that it could also be attributed by different skill of teachers teaching the two sections.

Figure-3. Grade Distribution for Sustainability Assignment and Final Grade

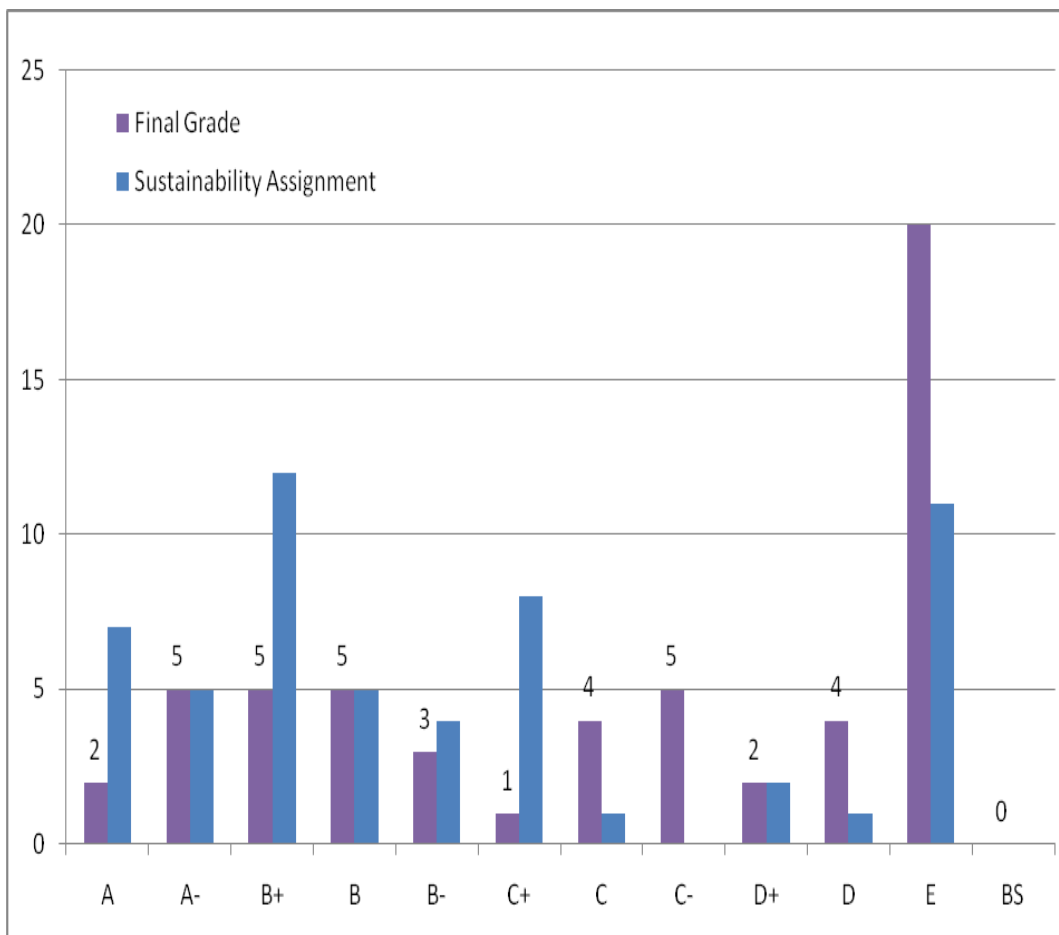
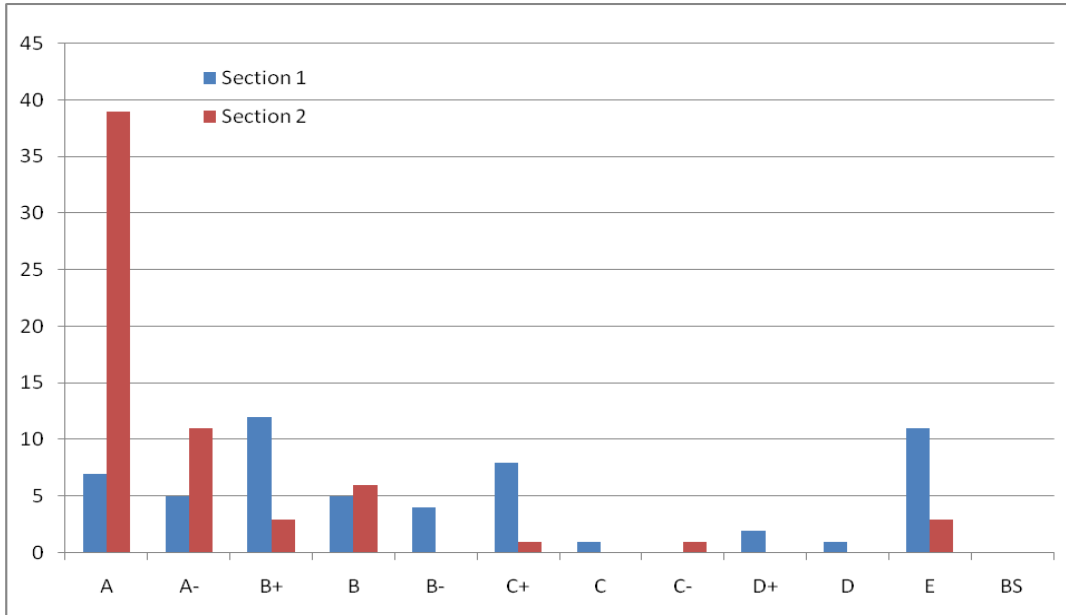


Figure-4. Grade Distribution for Sustainability Assignment in Different Section

4. CONCLUSION

This study investigates the effectiveness of the introduction of sustainability concepts at the early stage in a bachelor degree program for engineering student in UNITEN. Thermodynamics 1 course is chosen for analysis due to the fact that the subject deals with the fundamental concepts of energy conservation and therefore make it easy to integrate the element of sustainability into one of the chapter application. It was found that awareness of the concept could be done by assigning a small percentage of the total marks for the course to an assessment that contain elements of sustainability. In this case, 5% weightage is reasonable for junior level course and the weightage could be increased should the need to raise the awareness on sustainability increases. The contribution of this assessment towards the final grade of the course was found to be insignificant but sufficient enough to impart knowledge and understanding of the sustainability concept to the students.

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