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Structuring and Managing an Engineering Design Education towards the Effectiveness of Outcome Based Education System

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Abstract. Malaysia is moving forward towards the effective implementation of outcome based education (OBE) system. As one of the steps for the enhancement of Malaysian knowledge to initiate and design new technology and product, implementation of systematic and innovative tools and methods through OBE system in the stage of structuring and managing engineering design education among institute of higher learning (IHL) is very much essential. In this study, our aim is to develop systematic teaching tools for the structuring, managing, monitoring, assessing and analyzing the engineering design education towards the effectiveness of OBE system using user friendly software. Systematic teaching scheduling was created to reflect the actual practice in industry for the benefit of both lecturers and students. Structural weightage index was formulated and utilized in organizing and preparing the overall lecture plan to ensure appropriateness of the lecture content and finally lead to the improvement of the teaching and learning activities. Using the index, suitable number of sub-chapter was identified and this has led to the optimum usage of lecture time. It was also observed that the overall student performance was increased in accordance with the utilization of the proposed tools.

Keywords: Engineering Design Education, OBE, Structural Weightage Index, Course Assessment.

1. Introduction

During the announcement of Sixth Malaysian Plan in 1991, the late Prime Minister, Tun Dr Mahathir Mohamad had introduced the Vision 2020. It is a vision to achieve a self-sufficient industrialized nation by the year 2020, encompasses all aspects of life, including the economic prosperity [1]. In the report entitled Developing Malaysia Into A Knowledge-Based Economy by the Economic Planning Unit (EPU), Prime Minister's Department Malaysia, reinforcement on Malaysia's capability to innovate; adapt and create indigenous technology; and design, develop and market new products, thereby providing the foundation for endogenously-driven growth was highlighted and stressed to support the Vision 2020 [2]. This is partly consisted in the engineering design knowledge. In accordance with the International Engineering Alliance (IEA), engineering design knowledge is a knowledge that supports engineering design in a practice area, including codes, standards, processes, empirical information, and knowledge reused from past designs [3]. Thus, in order to achieve the national vision that emphasizes on Malaysian ability and proficiency to initiate and create new technology or product, implementation of innovative educational tools and techniques in managing, delivering and assessing engineering design knowledge are very much essential.

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As Malaysian Engineering Education moved towards becoming a signatory member of Washington Accord (WA) in 2004, there is a significant requirement for Malaysia to shift from the traditional educational (TE) system towards outcome-based education (OBE) system [4]. Under the OBE system, there are a few requirements that were set up by Engineering Accreditation Council (EAC) of Malaysia as a body delegated by Board of Engineer Malaysia (BEM) for accreditation of engineering degrees and the requirements are also in line with the requirements of WA. According to the EAC Manual 2007, an engineering programme seeking accreditation shall respond to the following requirements [5]:

- Programme Objectives: The programme shall have published Programme Objectives.
- Processes and Results: The programme shall have a clear linkage between Programme Objectives and Programme Outcomes; the process of ongoing assessment and evaluation that demonstrates the achievement of Programme Objectives with documented results; and the evaluation results are used in the continual improvement of the programme.
- Stakeholders Involvement: The institution of higher learning (IHL)/faculty shall provide evidences of stakeholders' involvement with regards to (i) and (ii) above.

As one of the courses conducted with project oriented problem based learning (POPBL) basis, the construction and management of overall syllabus for the engineering design course appropriately is very important. Based on R.M. Abdulaal et al., a project-based active/cooperative design course is planned to allow freshman-level students to gain professional hands-on engineering design experience through an opportunity to practise teamwork, quality principles, communication skills, life-long learning, realistic constraints and awareness of current domestic and global challenges. They have studied on the direct and indirect assessment tools that indicated a high level of achievement of course learning outcomes and a high level of student satisfaction [6]. In this study, the overall consideration in constructing and managing the engineering design course including the setting of course learning outcomes (CLO), content, assessment; direct or indirect method, frequency, weightage, and level of complexity, and so on are reported. The main objective of this study is to identify the appropriate and innovative teaching tools for structuring and managing the course using certain criteria that will be introduced later.

2. Overall Outline and Methodology

2.1. Overall Outline

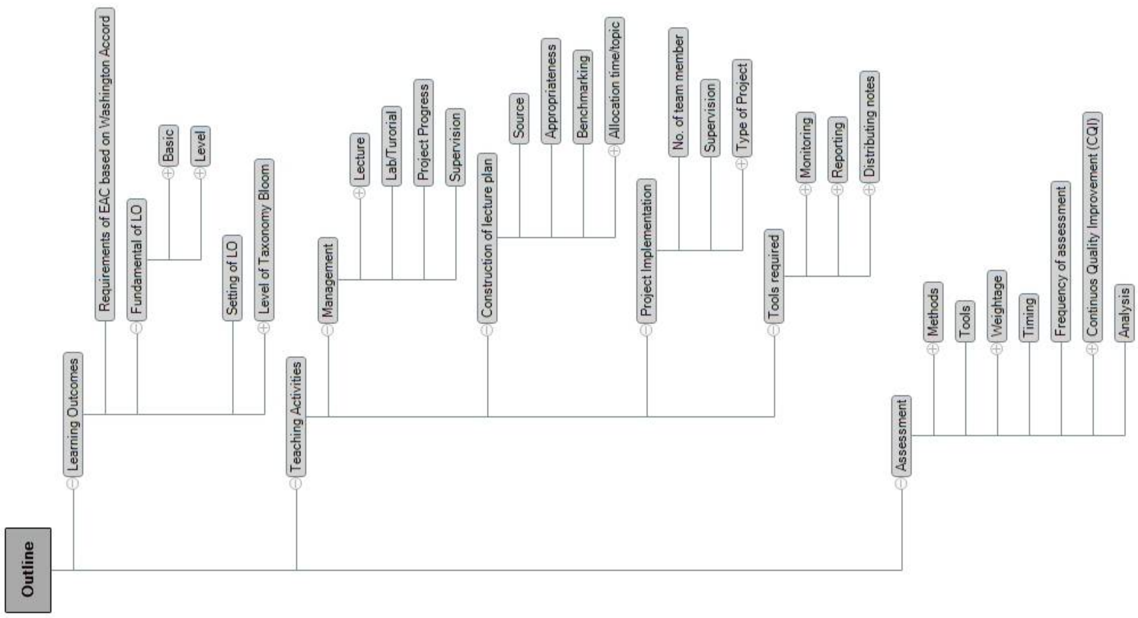

Fig. 1: Overall outline for the study.

Fig. 1 shows the overall outline for the study. It can be mainly divided into three main items; learning outcomes, teaching activities and assessment. Under the learning outcomes, some of the subjects that must be considered are as follows:

- Requirements of EAC based on WA
- Fundamental of LO
- Setting of CLO

In term of the teaching activities, the main agendas are stated below:

- Management
- Construction of lecture plan
- Tools involved

Finally, the assessments are conducted considering the following items:

- Tools and Methods
- Weightage; how to set the weightage of each assessment method
- Frequency
- Continuous Quality Improvement (CQI)
- Achievement analysis

In this paper, we are just focusing on the management of teaching activities, construction of syllabus, assessment method and weightage as well as tools for the achievement analysis.

2.2. Methodology

The overall methodology is as follows.

- Step 1: Identify suitable tools for management of teaching activities; lecture, lab, project supervision, attendance including reminder, and so on.
- Step 2: Construction of lecture plan; appropriate content, setting of time frame for each topic.
- Step 3: Identify tools involved in teaching and assessing student achievement.
- Step 4: Recognize appropriate assessment and analyzing method in accordance with the LO.

3. Results and Discussion

3.1. Tools for the Management of Teaching Activities

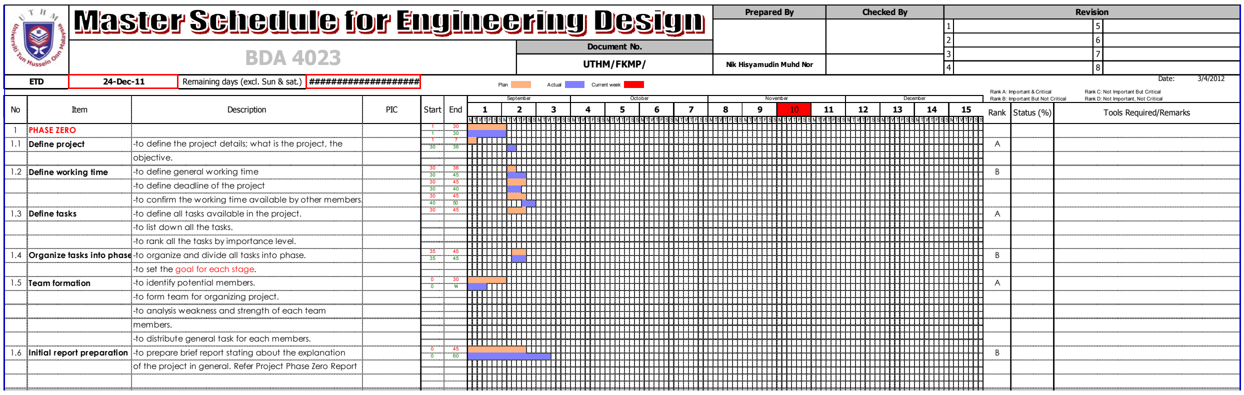

Fig. 2: Detail master schedule for the management of teaching activities.

In making the teaching activities more engineering oriented, the preparation of teaching planning and scheduling is made in detail so that there is a significant differences between the typical Gantt chart. The use of typical Gantt chart that consists of only the main activities throughout the overall teaching period not only limits the lecturer's ability of critical thinking in managing teaching activities but also could give a wrong intuition to the students on the actual managing method utilized in the real engineering world. Fig. 2 shows the master schedule for the engineering design course. It was constructed for planning, monitoring, and assessing the overall teaching progress. Automatic highlighting of the current week enable lecturer to confirm their position with one single glance.

3.2. Construction of Syllabus

One of the main aspects in constructing the course syllabus is to identify the appropriate content to be delivered in the course. There are variety of books with various numbers of chapter and sub-chapter. In this study, we have set the appropriate teaching time for each chapter using the Structural Weighting Index (*SWI*) with consideration of Complexity Level (*C*), Importance Level (I_m) and Intensity Level (I_n) as in Table 1 with the following equation:

$$SWI_{(i)}\,[\%] = C_{(i)} / \sum C \times W_c + I_{m(i)} / \sum I_m \times W_{Im} + I_{n(i)} / \sum I_n \times W_{In} \quad (1)$$

Where subscript (i) is the chapter number, and *W* is the weightage of each criteria. $\sum C$, $\sum I_m$ and $\sum I_n$ are total complexity level, total importance level and total intensity level respectively. Allocated time (T_a) for each chapter is given as:

$$T_a\,[\text{hour}] = \text{Round}(SWI_{(i)} / \sum SWI_{(i)} \times \sum H) \quad (2)$$

Here, $\sum H$ [hour] is the total of teaching time allocated. The results calculated using this equation are shown in Table 2.

Table 1: Summary of Structural Weighting Index (SWI)

Rating	Level of Complexity (C)	Level of Importance (I_m)	Level of Intensity (Sub-chapter #) (I_n)
10	**Extremely Complex**	**Extremely Important**	**>=15**
9	Very complex	Very Important	14
8	Complex	Important	13
7	**Very Difficult**	**Significant**	**12**
6	Difficult	Considerable	11
5	Less Difficult	Moderate	9-10
4	**Moderate**	**Relevant**	**7-8**
3	Easy	Less Relevant	5-6
2	Very Easy	Not Too Relevant	3-4
1	**Extremely Easy**	**Irrelevant**	**1-2**

Table 2: Time allocated for each chapter calculated using SWI.

Criteria	Weightage (*W*)	Engineering design process and methodology	Identification of Needs and Establishing Specification	Conceptual Design	Embodiment Design	Detail Design	Prototyping and Case Studies of Product Development	Sustainability and Environmental Consideration in Engineering Design	Economic, Costing, and Business Plan	Total
Complexity Level (*C*)	40%	2	8	7	10	1	1	5	4	38
Importance Level (I_m)	40%	5	9	8	10	4	4	4	4	48
Intensity Level (I_n)	20%	3	9	4	10	3	3	5	4	41
SWI	100%	8%	20%	16%	24%	6%	6%	11%	9%	100%
Time allocated		1.5	4.1	3.2	4.7	1.2	1.2	2.2	1.9	20.0
Round time (T_a)		2.0	4.0	3.0	5.0	1.0	1.0	2.0	2.0	20.0

3.3. Assessing and Analyzing Student Achievement

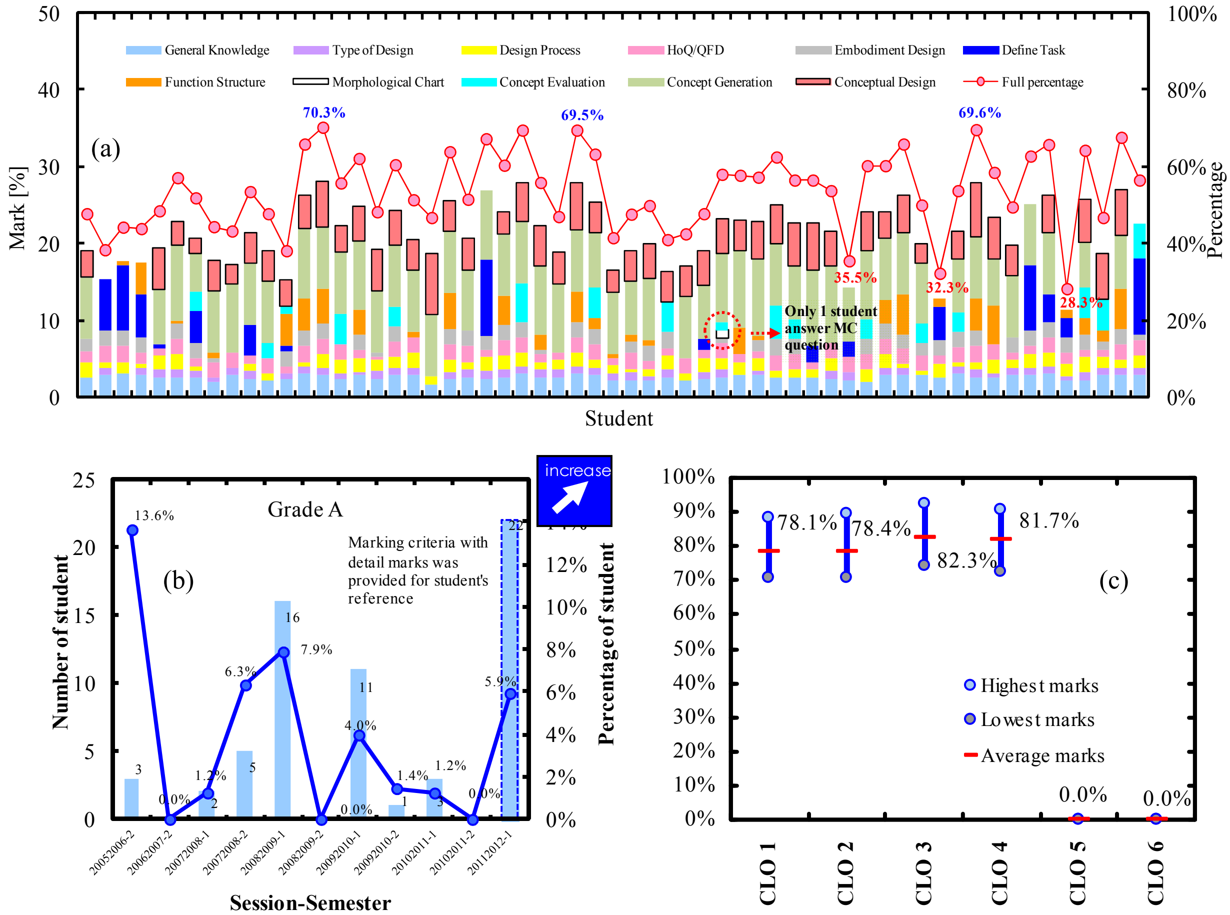

Fig. 3: Example of assessment and analysis made for student achievement; (a) Detail marks for test, (b) Achievement history from 2005-2011, (c) CLO achievement.

Fig. 3 shows the example of assessment and analysis made at the end of the course. Assessment method was made by considering knowledge, practical and soft skill needs and the weightage of each assessment method was also calculated using the method similarly to the equations (1) and (2). Systematic and innovative teaching tools not only can contribute to the better organization and management of overall teaching activities but also could contribute to the improvement of student's achievement.

4. References

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