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Student Learning Outcomes Accomplishment through Design Project

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***Abstract*—In accreditation process, it is tremendously challenging in meeting all the SLOs (Student Learning Outcomes) in a pure engineering course, as the SLOs generally consists of more than 50% of non-engineering attributes that to be cultivated for engineering graduate. A pedagogy approach in supporting engineering courses to accomplish the SLOs that involves humanity, social science, management and economy is proposed and implemented in this work through design projects.**

Keywords—accreditation, design project, learning objectives, pedagogy, student learning outcomes;

I. INTRODUCTION

Accreditation of an educational institute is getting more and more acceptance worldwide. It helps authority bodies to determine if an educational institute meets the minimum standards of education quality. At the same time, the students could take accreditation as basic guideline in enrollment of an institution. Institutions that accredited under the same accreditation body could have credits transfer and also supporting each other curriculum in a more sustainable approach. In this context, Washington Accord under International Engineering Alliance [1] has provided a framework to help mutual recognition on tertiary-level qualifications in engineering at international level. At national level, each country has her own accreditation body that support the accreditation process for qualified institute. The accreditation process and standard must compliance with Washington Accord. To make the institute curriculum is compliance and be able to meet the accreditation criteria, each qualified institute should be equipped with an accreditation committee or department to coordinate the internal curriculum committee with the external accreditation body.

There are many courses and departments in a typical tertiary-level institution which is fairly complex due to the divergence nature of the course contents. Thus, the accreditation committee in the institute face the herculean task of coordinating SLOs and the assessment activities of various courses at different levels and different departments, even though the accreditation in this case focuses on engineering.

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The instructors of various courses also encounter challenges in meeting both LOs (Learning Objectives) at the course level, as well as SLOs at the university level. The accreditation committee task is more complicated with engineering, science and mathematics related courses where technical intensive LOs are the only focus. In this case many of the SLOs that related to humanity, social science, management and economy are not be able to be measured and achieved effectively. Conventionally, to mitigate this issue, a few courses that related to those SLOs are purposely set up in order to meet the accreditation requirement. However, this approach still cannot actually produce the student with the desired attributes effectively. On the other hand, integration of the SLOs into the courses at course level could resolve those problems holistically. The question now is how to integrate those SLOs without losing the technical focus for engineering, science and mathematics courses.

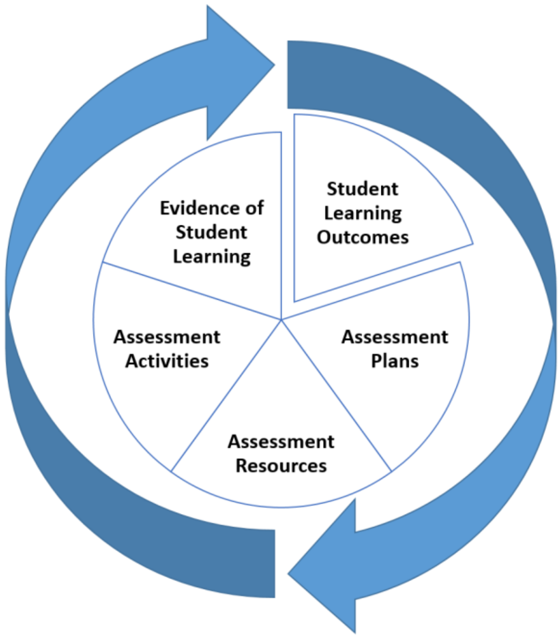

Figure 1. Components of Student Learning Assessment

The course level SLOs approach is implemented through design project achieve this goal. This is the main contribution in this work. Before describing the approach, it is also important to understand the ultimate goal of the SLOs. Under the complete framework of SLA (Student Learning Assessment), SLOs clearly state and list the expected knowledge, skills, attitudes, competences, and habits of minds that students are cultivated to acquire in their tertiary learning period. SLOs must be first introduced and subsequently decides the Assessment Plan, Assessment Resources, Assessment Activities, and followed by Evidence of Student Learning, as depicted in Figure 1. In this context, SLOs is the most important feature in running the institution in term of successful education. An engineering student that has gone through the process of learning under this frame work should has a holistic education background that help one to contribute to the society in various aspect of technology, humanity, art, sociology and economy. The SLOs has this positive aspect of producing graduate that not only focus on engineering and science, but also appreciate the social responsibility.

This paper is organized as follow. Section-II describes the SLOs component that associates with the topic of study in this work. The detail implementation of the course level SLOs is then discussed in Section-III, which is illustrated with an example. Section-IV concludes the paper.

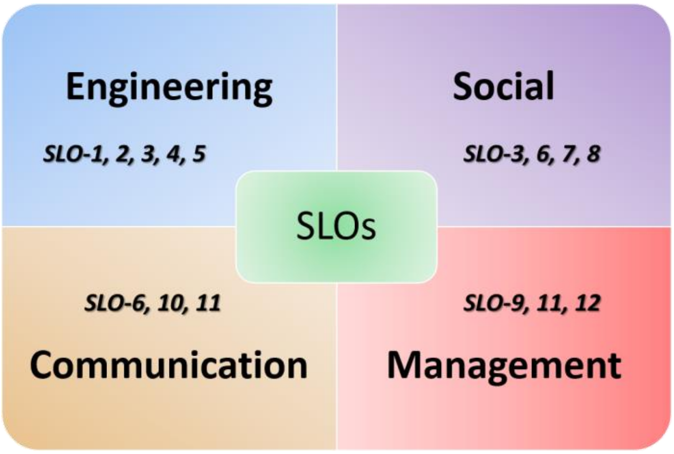

Figure 2. SLOs main categories and coverage

II. Elements of Student Learning Outcomes

The main elements of the SLOs cover various aspects include engineering, social science (environment, safety, ethic, life-long learning), communication and management. Example of the SLOs for an engineering degree are listed below for discussion:

1. Apply knowledge of mathematics, science, engineering fundamentals to the solution of complex engineering problems.
2. Identify, formulate, research literature and analyze complex engineering problems.
3. Design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations
4. Conduct investigations of complex problems using research-based knowledge and research methods.
5. Create, select and apply appropriate techniques, resources, and modern engineering and IT tools.
6. Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.
7. Understand the impact of professional engineering solutions in societal and environmental.
8. Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.
9. Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.
10. Communicate effectively on complex engineering activities with the engineering community and with society at large.
11. Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team.
12. Recognize the need for, and have the preparation and ability to engage in independent and life-long learning.

The above listed SLOs varies slightly from one engineering institution to another. One can refer to [2] for another similar SLOs. In this work, the SLOs are categorized into engineering, social science, communication, and management, with engineering as core. The related SLOs to each category are summarized as shown in Figure 2. It is clear that among the twelve SLOs, there are five SLOs only as hard core engineering oriented outcomes. However, it does not mean other SLOs are not engineering related, but the outcomes aim to achieve other responsibilities and skill besides engineering, which are social responsibilities, communication skill and management skill. The SLOs equip engineering students with a holistic set of attribute to contribute to the society.

SLOs in engineering categories can be achieved through course delivery in related engineering courses. How about the other SLOs? To cover those SLOs, courses such as Engineering Management, Ethic of Engineer, Resource Management, Writing & Presentation Technique, and etc. are commonly proposed and taken by the students. They are courses that are delivered separately from engineering courses, and most like decoupled from those engineering courses. If studied carefully, the SLOs actually require one to apply engineering skill as a core to serve the non-engineering SLOs.

For instance, SLO-3 (Design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations) requires the student to apply engineering design skill to solve a problem by considering the social issue. This strong linkage between engineering and non-engineering SLOs must be addressed as a whole. It should be emphasized not only through a single course, but has to be included in most engineering courses.

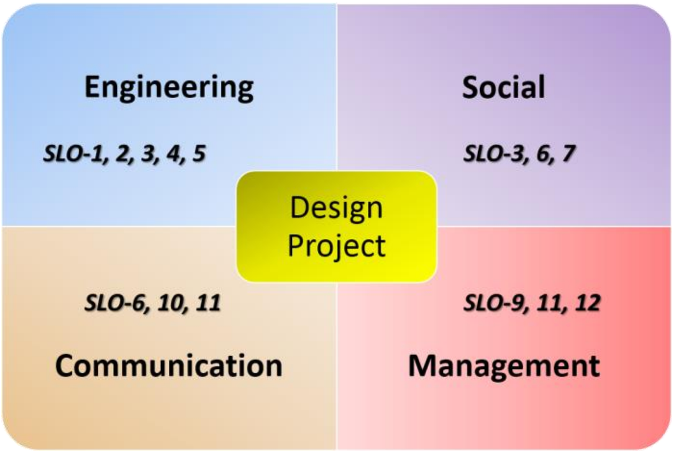

Figure 3. Design project with achievable SLOs

A. *Course Measurable Outcomes*

For an engineering course, the LOs maybe exist before the SLOs exist due to the participation of the Washington Accord of an institution recently. Washington Accord only established in 1989. It is worth now to take one engineering course's MOs (Measurable Outcomes) for discussion. The MOs for Introduction to Power Electronics is listed as below:

1. Distinguish and summarize various characteristics of power semiconductor devices.
2. Choose, match, and implement the appropriate power electronic technologies for their specific applications, such as power supplies, motor drives, and green energy sources.
3. Explore different analysis techniques and calculate the required parameters in designing basic power electronic circuits including ac-ac regulator, inverters, rectifiers, and dc-dc converters and assess the performance of the circuit.
4. Utilize the analysis method and calculate the required parameters in designing magnetic components and filters for power electronic circuits.
5. Formulate, explain, and assess the impacts of power electronics devices for the electricity supply utility.
6. Distinguish and summarize the types and features of different green energy sources.

It is very obvious that the above MOs cover only the engineering aspect of the SLOs (Figure 2). In this case, how to embedded the SLOs' element into an engineer courses? It is definitely not wise to conduct social science, communication, and management lesson in this engineering. Problem based design project could be one of the most effective approach that can help to achieve the SLOs at subject level. Since the non-engineering SLOs are essentially application of the engineering subject, the SLOs can be achieved more effectively through crossed-subjects design project [3]. In this discussion, Introduction to Power Electronics, and Microelectronic Circuits & Devices are the two subjects that is involved in this crossed subjects design project in SLOs accomplishment.

B. *Crossed-Subject Design Project Measurable Outcomes*

For this purpose, the MOs of the design project should cover SLOs in social responsibility, communication, and management. The communication comes naturally in the project presentation, report, poster, video, and demonstration. However, detail marking rubric for performance evaluation in this communication should be set, in order for the students to prepare and achieve the rubric. The design project is group base and the students should be taken both subjects. This indirectly trains the team work, and management skill. Similarly, the expectation should be set for this SLOs. The core of the design project should be rooted at adopting the content of the engineering subjects in solving social or environmental problems. The MOs of the design project can be listed for clarity:

1. Apply engineering knowledge learnt from the interdisciplinary courses in carry out research and design a product by considering public health and safety, cultural, societal, and environmental considerations.
2. Demonstrate effective and efficient management principal in implementing the design project as a group with emphasis of individual contribution and leadership to the group success.
3. Demonstrate profession in design use communication skills - oral, graphical, and written - in all aspects of their technical work with innovative and effective presentation skill in delivery of the technical content.

The achievable SLOs by adopting problem base design project across subjects is shown in Figure 3. It can be seen that most of the SLOs can be achieved to a high percentage depends on the depth and breadth of the courses and design project. Note that SLO-12 for life-long learning is not accessible at this stage. Besides achieving the SLOs at subject level, the design project with SLOs emphasis could definitely provide a strong linkage as well as relevancies between the engineering courses and their roles in practical application in industries. The design project actually effectively enhances the learning and teaching. The course work delivery is through JiTT (Just-in-Time Teaching) instead of structured lesson flow to make sure the theoretical discussion is application oriented [4]. The possible caution is to manage the expectation for not overload the students and the instructors, as the design project requires substantial amount of effort and resource. One of the design project will be discussed in the next section of the text.

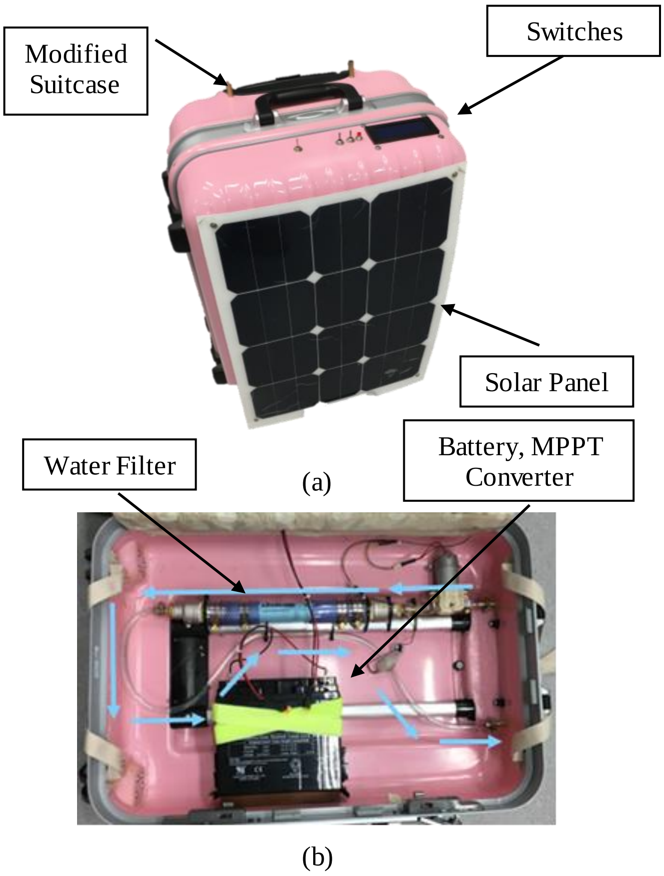

Figure 4. Disaster relief kit

III. Design Projects

The project is designed based on both the course's MOs (Section II.A), and project's MOs (Section II.B). The project is about design a product that making use of alternative energy (solar, hydro, bioenergy, wind) to solving a societal or environmental problem. There are three phases in this design project:

- Phase-I: Design and construct an alternative energy system, e.g. solar energy system using off-the-shell module.
- Phase-II: Design the module at component levels to replace the off-the-shell module to optimize the system performance.
- Phase-III: Integration of various modules for a complete product. The product must address the solution to the problem statement that related to the societal or environmental issues.

There are all together 6 project groups this time. A project with title of "Disaster Relief Kit" is used as an example for discussion in this text. The product name is "*StrawBerry SunShine*" as shown in Figure 4, which is named after integrating water filter from LifeStraw® (http://lifestraw.com/) in solar (sun) energy system in an eye catching pink color suitcase. The design is able to provide clean drinking water for affected victims after natural disasters via a filtration system which is solar powered. It is portable and easily moved to the affected venue. The product is also equipped with battery and dc-ac converter to supply ac power which is lacking during disaster. It worth mentioned that beside the water filter, the students are able to design the rest of the devices from basic components by implementing the knowledge learnt in the courses. Most of the SLOs was addressed through this design project.

IV. Conclusion and Assessment

A checklist was created to assess the accomplishment qualitatively. The checklist consists of a mapping table for SLOs with subject's MOs and subject design project MOs. All the projects (6 groups, 30 students) is able to meet the SLOs through the project MOs as expected due to the project requirement and assessment criteria. In nutshell, this work shows that the SLOs can be effectively achieved through problem base design projects with proper set of MOs. The advantages of the course level SLOs are also reducing the accreditation process, more in-depth and breadth achievement of the SLOs. Again resources in funding, space, hardware, software and etc. are demanding in the exact implementation.

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References

[1] International Engineering Aliance, 'The Overview of Washington Accord', 1989. [Online]. Available: http:// www.ieagreements.org/ Washington-Accord/ The Overview of Washington Accord.pdf. [Accessed: 12-Jun-2015].

[2] National University of Singapore, 'Student Learning Outcomes', 2015. [Online] Available: https:// www.ise.nus.edu.sg/ about_us/ student_learning_outcomes.html. [Accessed 12-Jun-2015].

[3] T. Hui, Teo, "An effective interdisciplinary teaching and learning methodology through crossed-subjects design project - an experience sharing," *submitted to GSTF Journal on Education (JEd)*.

[4] T. Hui Teo, "Just-in-Time Teaching visual instruction for cohort base interactive learning-for engineering course," GSTF Journal on Education (JEd), vol.3, no.1, 2015.

[5] W. J. Lee, eq al., "Disaster relief kit," Power Electronics & Microelectronics 2D Project Report, 2015.

AUTHOR'S PROFILE

T. Hui Teo graduated with Master of Engineering and Ph.D. from National University of Singapore and Nanyang Technological Univsersity in 2000 and 2009 respectively in Electrical & Electronic Engineering. Since 1996, he was with Sharp, ST-Microelectronics, Intelligent Micro-Devices (Matsushita), and etc. as a senior Integrated Circuits (IC) designer, prior joining Institute of Microelectronics, Agency for Science, Technology and Research (A*STAR), Singapore as principle investigator in advanced IC design R&D. In 2010, he joined education sector for setting up both Analog and Digital IC design courses and laboratories for Technical University of Munich, Asia. He is currently with Singapore University of Technology and Design. His research interest are IC design, device characterization & modelling and design education. T. Hui is a Senior Member of IEEE, and Fellow of IES (Institution of Engineers Singapore).