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# Green Engineering Education in Environmental Engineering Programme through Active Learning

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**ABSTRACT:** Over the last few years, there has been considerable growth in incorporating sustainability and green engineering into construction industry development. The need to use resources efficiently while minimizing environmental consequences is becoming increasingly important in the industry; as a result, green engineering content is gaining traction in engineering curricula. assessment is a technique used to determine students' understanding of what they have learned in class. The outcomes assessment results are part of a feedback loop in which academics are given information to help them improve their teaching and student learning. This paper talks about the different ways students can show what they've learned in the course Environmental Considerations in Construction.

**KEYWORDS:** Green engineering; course description; active learning; assessment

## 1. Introduction

Modern education has introduced sustainable engineering to address the causes and impacts of development on the environment. Sustainable engineering comprises technological systems, services, and appropriate design products in engineering fields, specifically civil construction. This leads to environmental and social performance globally [1]. However, there are some pressing challenges that rapid population growth poses: environmental pollution, depletion of materials and energy, and damage to the ecosystem. Green engineering is seen to be one of the most effective methods for attaining long-term industrial growth [2]. while the decision-making role is merely based on the current situation's costs in the engineering aspect. The cost is not considered the upcoming price to civilisation from the destruction of society and the environment. Thus, it allows us to produce products at a low price with low quality. We have to study the product's lifespan and observe communal aspects rather than only the cost of resources and energy [3].

For sustainable development to be achieved in industrialised and developing countries, it needs to be taught at the bachelor's level. Thus, the engineering course program has included green engineering in application and implementation [4]. Green engineering education aims to prepare students to become professionals capable of meeting converging global environmental challenges and considering broader societal factors driving green engineering and sustainable development [5]. Several engineering and science academic institutions in many countries have implemented green engineering as the main topic in their core undergraduate or postgraduate programs. Furthermore, many funders invest in research and training to support the practice of green engineering [6–8]. The green engineering/chemistry course is implemented in academic degrees and graduate education courses as a compulsory subject for students majoring in chemistry or materials at the University of Science and Technology of China. Similarly, green engineering was introduced to the doctoral program at Sichuan University in China, improving scientific literacy among the graduate students and enhancing their corresponding chemistry skills [9].

The current teaching style for undergraduate subjects is based on traditional lecture-explanation of lecture content and home assignments, with little or no interaction and input from students throughout the learning process. This article provides a brief framework of how active learning could be used to assist engineering students at Curtin University Malaysia learn about green engineering.

## 2. Discussion

### *2.1. Active learning*

The term "active learning" was first popularized by Bonwell and Eison [10], who defined it as "anything that involves students in doing things and thinking about what they are doing." By definition, active learning can be described as any technique involving students in the learning process via in-class activities, focusing on higher-order thinking and group work to stimulate students to think extensively about their learning progress and accomplishments [11,12]. Students gained knowledge through active learning by reviewing lecture notes and devices and responding to two questions prior to class. According to Bloom's revised taxonomy, this practice stimulates students' higher-level thinking [12]. It also expanded the thoughts beyond the reading to make them relevant to the student's life, which was intended to increase their interest and drive to learn [13,14]. Active learning is based on constructivism theory, which states that students must actively engage with the content in order to understand it [15-17]. concepts of the constructivist theory include the following: learning is self-centred and self-directed; learning is an active rather than passive undertaking; and the instructor's duty to stimulate critical reflection and support the application and better understanding of new ideas [18,19]. Extensive research has demonstrated that active learning strategies are typically more successful than traditional lectures as students only gather the information from the lecturer as the expert of knowledge [20-22]. In comparison, the active learning alternative is more exciting. Students enhance critical thinking skills by participating in a few activities, including think-pair-share, flipped classrooms, games and simulations, a 1-minute paper, real-life discussion, case studies, and debates [23,24]. In literature, a typical student's attention span was 10–20 minutes, and that focus dropped after roughly 10–20 minutes [25]. Thus, hands-on, interactive, and collaborative learning in class is required to improve engagement.

### *2.2. Green engineering courses and curriculum*

Green engineering is a great introduction to the engineering education environment with the intention of producing future green engineers. In many countries, the principle of green engineering has also been incorporated into the university curriculum in the form of research programmes, courses, and master's programmes. Education in green engineering should be founded on the following principles [26]:

a) It's important for green engineering courses to have clear training goals and a framework that covers the whole manufacturing process, resources, the environment, and how to use the finished product.
b) It is critical to create a framework for green engineering courses that is tailored to the needs of the sector and the local economy. Green manufacturing knowledge and skills, as well as green behaviour, attitude, and values, should all be included in the training framework. It should be based on improving teaching skills and internship training.
c) It is critical to enhance the concept of green manufacturing and have a deeper grasp of green manufacturing technology, processes, and viability through corporate practice, as well as to apply various green manufacturing technologies to various sections and build total energy consumption arrangements.
d) It is vital to offer businesses via theoretical research, which complements current technologies and improvements in measures for green manufacturing implementation plans.

Green engineering courses are available at universities, and some are offered in collaboration with the corporate sector. The development of new courses and curriculum should be closely linked with assessment in order to determine implementation and outcome success. Assessment data assists in iteratively improving current courses and providing legitimacy to a new curriculum, promoting staff and student buy-in [27,28]. Researchers apply a wide variety and mix of qualitative and quantitative measures to evaluate student understanding [29,30], perspectives, engagement, values [27,28], and communication [31] of green engineering. These assessment methods were selected for their capacity to swiftly and effectively measure intended learning outcomes.

### *2.3. Course description*

As sustainability becomes more generally recognized [32,33], many green engineering-related electives have been created at the university level, including the Environmental Considerations in Construction (ECC) course. The ECC course has been taught to students at Curtin University Malaysia in the Faculty of Engineering and Science (FOES) since 2020. Students at FOES, including those in other programmes, may enrol in this course and earn general education credits. ECC has a 25 credit value, which is equal to four credit hours according to the Australian University system. This course has been developed to build a theoretical and practical foundation of green development that covers erosion and sedimentation control; air quality; noise and vibration impacts; water quality and ecological management; contaminated land management; waste management; and green building technology. Upon completing the course, students are expected to gain knowledge and the ability to explain, plan, and identify the theoretical and practical elements. According to the course framework, all topics are orally presented via a PowerPoint presentation, discussed in class, and some product design is assigned as a team project. The new way of teaching was set up by having students talk about a real-life problem in class as part of Problem-Based Learning and by having them make more complex products and give presentations as part of Project-Based Learning.

The topics taught in ECC are led by the Programme Outcomes (POs), which serve as a basis for achieving Curtin Graduate Attributes upon graduation and achieving Program Educational Objectives (PEOs) in a few years, and contribute to the University's Vision and Mission. This is accomplished via a model in which course evaluations contribute to course learning outcomes (CO) and ultimately to the PO. Also, it is necessary for lecturers to describe the course outline to students in the first week of semester commerce. The explanation lists the learning activities, learning resources, assessments, and the course map to the CO that were done during the course.

### *2.4. Match Between POs and Courses*

In order to include sustainability as a design criterion, the course must fulfill the POs, which are related to the skills, knowledge, and behaviors that students gain throughout the program. These POs are a set of guidelines that students should know and be able to accomplish or achieve by the time they graduate. The 12 POs of the engineering program can be simplified as follows:

Programme Outcome 1 (PO1): Engineering Knowledge
Programme Outcome 2 (PO2): Problem Analysis
Programme Outcome 3 (PO3): Design/Development of Solutions
Programme Outcome 4 (PO4): Investigation
Programme Outcome 5 (PO5): Modern Tool Usage
Programme Outcome 6 (PO6): The Engineer and Society
Programme Outcome 7 (PO7): Environment and Sustainability
Programme Outcome 8 (PO8): Ethics
Programme Outcome 9 (PO9): Individual and Team Work
Programme Outcome 10 (PO10): Communication
Programme Outcome 11 (PO11): Project Management and Finance
Programme Outcome 12 (PO12): Life Long Learning

The 12 POs form a design framework that is interrelated, indivisible, and mutually reinforcing. In an integrated system, it is critical to consider the 12 POs. If engineering improvements are only focused on a particular concept, replacing a current issue with a new one is risky. In order for students to comprehend the 12 POs, they must be introduced and presented throughout the course. The course corresponded to certain POs achieved via COs and assessments, as shown in Table 1. Before deciding, the program committee considered the link between the POs and the course or module in depth, which reflects the faculty expectations for course content and outcomes results based on students' performance [34].

**Table 1.** Programme Outcomes that match with Course Learning Outcomes.

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | ✓ | | | | | | | | | | | |
| CO2 | | | ✓ | | | | | | | | | |
| CO3 | | | | ✓ | | | | | | | | |

### *2.5. COs and POs Attainment*

The ECC ability has been broken into three COs: (1) CO1: Describe the principles of development approval processes and compare them to local development approval processes;

(2) CO2: Plan and propose best environmental management practices for a construction project; and (3) CO3: Identify and use green materials and technology in building design and occupancy. Through numerous ways, assessments have been done to establish whether or not a targeted student outcome has been reached. Direct and indirect assessment measures have been devised and employed to measure Student Outcomes' curricular accomplishments and offer a framework for continual program improvement. The tools include Course Assessment Records (CAR) and eVALUate Survey from students.

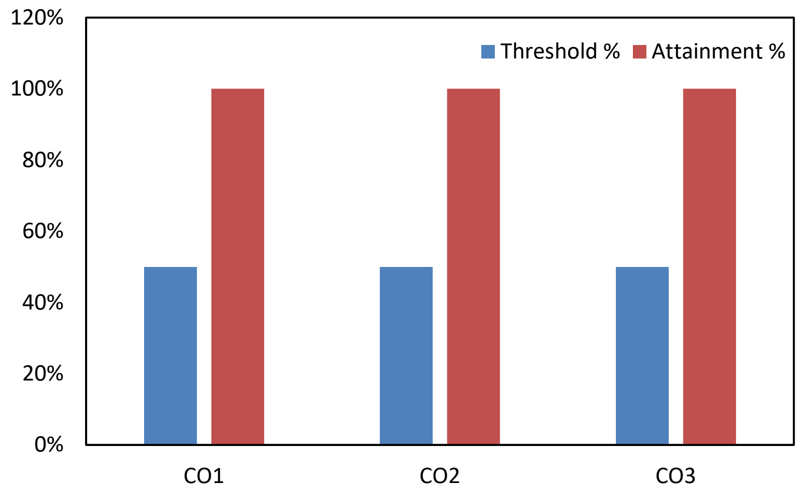


**Figure 1.** The three outcomes of ECC in 2020.

**Table 2.** The students' evaluations concerning one specific quantitative item.

| eVALUate quantitative items | Percentage Agreement | Percentage Disagreement | Percentage Unable to Judge |
|---|---|---|---|
| 1. The learning outcomes in this unit are clearly identified. | 100 | 0 | 0 |
| 2. The learning experiences in this unit help me to achieve the learning outcomes. | 100 | 0 | 0 |
| 3. The learning resources in this unit help me to achieve the learning outcomes. | 100 | 0 | 0 |
| 4. The assessment tasks in this unit evaluate my achievement of the learning outcomes. | 100 | 0 | 0 |
| 5. Feedback on my work in this unit helps me to achieve the learning outcomes. | 100 | 0 | 0 |
| 6. The workload in this unit is appropriate to the achievement of the learning outcomes. | 100 | 0 | 0 |
| 7. The quality of teaching in this unit helps me to achieve the learning outcomes. | 100 | 0 | 0 |
| 8. I am motivated to achieve the learning outcomes in this unit. | 100 | 0 | 0 |
| 9. I make best use of the learning experiences in this unit. | 100 | 0 | 0 |
| 10. I think about how I can learn more effectively in this unit. | 100 | 0 | 0 |
| 11. Overall, I am satisfied with this unit. | 100 | 0 | 0 |

When determining a student's PO achievement, the proportion of students who scored 50% or above on each examination is used. The weighted average of the assessment attainment is then used to determine the CO attainment. Finally, by averaging the PO attainment of each student in the cohort, the program-level PO attainment may be calculated. The CAR involves extracting specific categories of student work from several assessments, including assignments, reports, and examinations. A threshold, for instance, is set at 50% for all the abilities. The following is a sample of CO achievement for the ECC course for the 2020 academic year as presented in Figure 1. All of the PO attainment measured by the CAR is higher than those thresholds, which means the abilities related to ECC topics are indicated in a good state through assessments. Meanwhile, in 2020, a questionnaire study on ECC's impacts was conducted among students. The questionnaire survey was conducted on the self-evaluation of the eleven eVALUATE items for graduates in 2020, as indicated in Table 2. As listed in Table 2, students have given good ratings for all of the particular items. Students all agreed that the way the ECC course was taught helped them reach the learning goal.

## 3. Conclusion

Green Engineering Education has been introduced and improved to support future growth, especially with the help of the government, industry, and universities. It has placed a high value on green engineering, which has evolved into a necessary component. The 12 POs have been integrated into the engineering programme and specifically matched with the particular course. The link between the defined program outcomes and the ECC course demonstrates that the particular program outcomes have been addressed and presented in the curriculum. It has been incorporated into a number of active learning items such as reports and real-life scenarios in delivering the course. The students agree that they have succeeded in the ECC course through assessment by CAR and eVALUate Survey. Both imply that the ability is capable of meeting the requirements.

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