

Application of Effective Teaching and Learning Methods in Engineering Education

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The challenge that faces the education environment has always been to ensure that the teaching & learning (T&L) process takes place effectively in a classroom environment. This paper focuses on the authors experiences in implementing some active T&L methods in engineering education to promote effective student learning. It explores specific pedagogical strategies combined with university resources to improve the quality of teaching and student learning. A simplified educational model for improving the quality of the T&L process is presented. The model suggested that the effectiveness of the T&L process is dependant on the effective facilitation of communication, involvement and interaction among students, lecturers and course content.

Keywords: teaching, learning, T&L model.

Introduction

Excellence in engineering education comes from innovative teaching techniques and effective instructional materials. This would require one to change the traditional way of delivering engineering education. In the traditional teaching methods, lecturers offer course materials in a classroom where students listen, take notes, copy materials, execute homework and complete assignments. In many cases lecturers fail to transfer knowledge to students effectively despite personally having sound technical knowledge in the subject area. This occurs because it is often hard for students to take notes and listen with good comprehension simultaneously. In fact better teaching techniques do exist but often difficult and time-consuming. The literature on active learning is replete with methods of engaging students to promote more effective learning than the traditional lecturing approach [1, 2, 3]. Some educationists stressed the importance of cooperative learning, problem-based learning, and presenting information in various learning styles [1, 4, 5, 6, 7, 8].

The aim of this paper is to examine practical pedagogical practices, via the authors' observations, experiences, and studies that have been used successful within the context of engineering education at the Monash University Malaysia campus. The purpose of this discussion is to build the awareness of a variety of effective teaching ideas and techniques that a lecturer may consider in light of their current teaching styles and personalities. The authors have developed a T&L model to deliver a better understanding of the quality of students' learning.

A Simplified Teaching & Learning Model

The goal of teaching is to improve student learning by maximizing opportunities for learning in every lesson. Such improvement reduces wastage of university resources such as time, effort and money by producing students with the right skills and knowledge that delight the employers [9]. Figure 1 is a simplified model developed by the authors, to show how lecturer and student interactions should take place in the T&L process. Adopting this model requires lecturers to be more open to change in the methods of teaching and delivering course materials to students through the use of innovative teaching strategies and appropriate technologies. In this model, the lecturer takes steps to add value in the T&L process by transforming inputs that include actions, methods and operations into effective outputs for student learning. A strong feedback loop providing useful information about the degree and quality of learning perceived, is included and directed to the lecturer. The lecturer shall listen to the students in order to make continuous improvement to the design and delivery of information that is able to cause student to learn continuously in the acquisition of knowledge, experience, know-how, wisdom and character. The model empowers students to initiate actions to learn whereas the lecturer, through the process of assessment, makes continuous efforts to identify changes for the T&L process improvement. This model also requires the lecturer total commitment in teaching that takes full responsibility by actively causing the student to learn. The lecturer communicates the information of the subject matter to the students by simultaneously focusing and interacting with the students to motivate and get their attention to learn as well as continuously analyzing and determining the desired and necessary actions to improve the quality of T&L process. However, this improvement can only be effective when both lecturers and students work together to identify, analyze and make improvements to the T&L process. For ensuring success, this T&L process requires the support and the simultaneous working together of several resources from appropriate

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technology tools, academic and supportive staff, departments and faculties, student affairs, resource centers, and financial services. The use of better quality resources and positive environment will lead to better quality of T&L process.

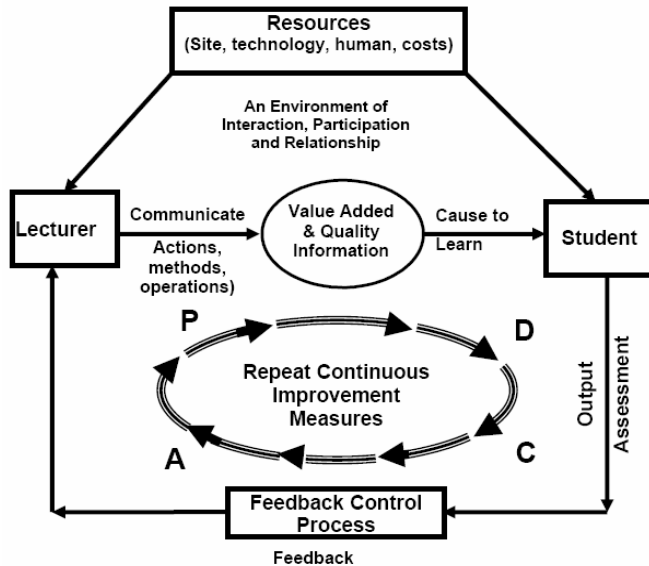


Figure 1: A simplified Model For Teaching & Learning

The output assessment for the T&L process flows into the feedback control process, which monitors and determines the corrective actions required for the next improvement stage. The continuous assessment and improvement of the T&L process is monitored by an infinite inner-loop process using Deming’s plan-do-check-act (PDCA) cycle. This continuous improvement process with on-going feedback provides the framework for evaluating objectives, assess outcomes, and improve the T&L programs and strategies that are critical for attaining and exceeding the T&L goals. The lecturer job is to define, monitor, control and deliver the T&L improvement process, and work continuously to improve the T&L process (e.g., content, delivery, competency, management, assessment, attitude, services, etc) by soliciting feedback from the students and drive the students to learn in incremental steps.

Our T&L model focuses on building effective communication and quality relationships among lecturers, students, and course contents. Knowing how these relationships work will allow one to organize and choose appropriate T&L tools and methods to make effective learning happens. Lecturers must effectively manage and organize the efforts of students in every activity of the T&L process so that they in turn can approach their learning with enthusiasm and in a participative mood. Therefore we need to focus on improving the quality of every actions and interactions in the T&L process such as improvement in the areas of teaching, subject designs and objectives, course notes & books, resources, staff-student interactions, assessments, subject evaluations, etc. The model ensures that every student involved in the learning process is assiduously meeting out their learning requirements. This learning requirements can be: more personal attention; use more interactive multimedia and visual application rather than all lecture; more lecturer-student interaction; more interesting, meaningful and practical or real life lecture contents that are presented with the latest technology; mark and return all student submitted coursework quickly; teach materials in accordance with the student’s level; give more demonstrations or hands-on approach to certain topics; provide timely and accurate information and services; and more group activities.

Our model also requires students to participate throughout their learning effort. This practice is important because the quality of T&L is linked together. For example, to make students learn, retain and use the information and material better, the subject topics should be taught by combining presentation with activities and constructive interaction. This requires us to design relevant materials/activities for maximum student participation that leads to dynamic and interactive exchanges in the classroom environment. This building of relationship with students involves care, respect, trust and openness. We find that one of the best ways to build relationship is to ask many questions as well as encouraging students to ask questions. Asking relevant questions and carefully listening to

student's answers allow one to determine the level of knowledge and maturity of the students, and what areas need further emphasis.

Classroom Performance

The model in Figure 1 suggested that effective T&L involves not only by lecturing but also by showing & involving the students to learn. Good lectures require lecturers to be well-prepared, and with the learning material well-organized, presented clearly and enthusiastically. Additionally during a lecture session, students need to be given ample opportunities to read/write, talk/listen, clarify, reflect, apply, and consolidate new knowledge from the course content. Some teaching strategies that are beneficial and useful in actively engaging students with the subject content include activities such as group discussions, problem solving exercises, simulations, case studies, and structured learning groups. The outcome in the T&L is to produce quality graduates with a good foundation in basic engineering and science, essential skills attributes, as well as equipping them with the essential knowledge and learning process and tools that they can creatively learn, analyse, synthesize new information, problems and tasks on their own.

Through classroom observations and student test records, it is found that motivational influence student learning. Student's motivation would be high when they possessed general desire to achieve, had self-confidence & self-esteem, and were patient and persistent. Our evaluation results also indicated that students can be motivated to learn by the usefulness of the material and learned better when material was related to their own needs and interests, and this result obtained is consistent with the findings in other published work [10]. One can adopt Maslow pyramid model as a first step to develop learning motivation for students [11] as well as to work with the students to remove the barriers to motivation. Using Lego blocks to experiment on human work behavior, the author [12] has demonstrated that motivation conclusively enhanced the learner productivity and efficiency in performing a work and learning task. Therefore, the certainty is that student needs to be motivated enough to pay attention in class. Therefore, lecturers need to begin each T&L session by motivating students, expressing positive expectations, and sharing their objectives with them.

The second observation indicates that students generally need more than one exposure to learn effectively for new or unfamiliar subject topics and/or to accommodate the needs of students with different levels of prior knowledge and different learning rates. An effective method to overcome this problem is to give the students enough time to learn the material being taught and to rephrase the explanations of many difficult but important points and concepts in the lecture session several times from a different directions/examples or in different words or equations or to present the points using multimedia technology. As was observed in a Lego experiment, the author [12] has shown that effective and increase learning can be achieved by frequent repetition of the same process when presented in different formats. That is, the use of repetition methods in an engaged and participative environment leads to increase learning as it maximize the chances that every student will eventually understand. In our class, we enhance student-learning experiences by developing the same major point in two or three different modes, e.g., mathematically, verbally, and graphically by combining with appropriate interactive multimedia technology tools.

The goal of T&L is also to create a supportive and positive environment that causes student to take initiative to learn through the process of engagement and participation in a class session. Table 1 shows some data of student performance using active and standard teaching techniques based on a specific engineering subject over a period of 3 years in a two-hour per week lecture session. The assessment per semester was based on two sets of tests conducted at Week 7 and Week 12 over a period of a 13-weeks semester. The result appears to show that maximum learning occurred when students were fully engaged in the T&L and course content. On the basis of this data, active T&L technique is more effective than traditional methods as far as generating student understanding of the material content is concerned. The longer the students stayed engaged in the lesson (via participating in the relevant learning activities), the more the student learns.

During the period between 2002 and 2003, the author [7] also carried out a survey on undergraduate engineering students on the improvement of instruction on two engineering courses. The students from this engineering program were asked to identify good classroom teaching practices in which they have a strong preference. The data were collected at the end of each semester period, and some of these generalized statements and preferences expressed by engineering students for good teaching practices are ranked, in decreasing order of importance, as follows:

1. Well-organized, clear and lively lecture presentations by making effective use of interactive computer technologies and software tools.
2. Able to promote active flexible learning by simulating interest, generate enthusiasm and motivation in them.
3. Using well-structured and practical course content that are connected with relevant learning activities.
4. Easy access of e-learning educational tools, web-based resources, library & IT resources to support their study.
5. Giving rapid and effective feedback for homework, tests, assignments, lab reports, etc
6. Openness, approachable and accessible to them.
7. Willingness to listen, respect and/or receive their feedback on a regular basis and/or acting upon their suggestions for improving the course and teaching methods.
8. Able to give clear explanation of course goals, expectations, grading and ground rules before course commences.
9. Willing to provide model answers for sample of exam papers, project work, assignments and etc.

This survey result appears to indicate that a majority of the students ranked "Giving well-organized, clear and lively lecture presentations by making effective use of interactive computer technologies and software tools " as the single most important teaching practice.

Table 1: Average test results shown by 3 types of teaching techniques: 2001, using traditional methods, and Year 2000 & 2002, using active T&L methods, but for 2002 students were given e-notes and WebCT access.

Summary of Assessment Data for Materials Engineering		
Year	1 st Semester Test (%)	2 nd semester Test (%)
By active T&L methods (2000)	55.7 (30 students)	57.3 % (47 students)
By traditional T&L methods (2001)	50.4 (57 students)	52.3 (37 students)
By active T&L methods (2002) Plus with e-notes and WebCT	68.5 (73 students)	67.1 (52 students)

Experiences in Teaching via Feedbacks

Getting reliable feedback information for every semester is essential as it will allow us to know how well the students are learning or how students respond to specific T&L approaches. Course grades, marks, certificates, syllabus, examinations/tests, in-class activities, student performance on tutorial problems, suggestion boxes, student critiques, peers & students feedback, surveys and evaluations are the resources that form part of the T&L process. For example, lecturers can examine set of graded papers for common error patterns, talk and listen to students about the graded papers, and check on their verbal understanding and skills of specific concepts that reflected in their submitted work. With this feedback information, students can have a clear indication of how well they are meeting the subject outcomes at that time and understand the quality of their work, what they need to change, modify, adapt and improve their work and/or performance. This constructive feedback, which diagnoses student difficulties, can lead to significant learning gains. The process of course improvement and delivery [13, 14] can be based on Deming's plan-do-check-act (PDCA) cycle that includes: identify gaps and variations from students' feedback; analyze instructional process; plan actions to improve quality; implement actions; and evaluate customer satisfaction surveys. For example, unlike in traditional classrooms where lecturers often follow this sequence: Plan → Teach → Test, but in the continuing, never-ending nature of process improvement model, we can adopt a Plan → Teach (Do) → Check and determine which learning outcome students have missed (Check) → Revised T&L (Act) → Test (Assessment), with each cycle producing improvement. This basic approach needs to be backed up with good T&L strategies, and requires one to have the passions and long-term commitment to constant improvement and/or to adopt important changes to pursue new and efficient ways of managing T&L process.

Feedback information can also be obtained from peers that comment on the quality of teaching and the quality of course materials delivered to students. Information and opinions collected from the peer reviews can be used to refine and improve the course goals, course activities, tests/examinations, and the accuracy and quality of the printed and distributed materials. The printed and handout notes must be made with clarity of explanations in all content specifications. In the observation of teaching, peers can use a pre-established rating questionnaire for recording information. Materials that do not meet certain specifications will be corrected. Class interview techniques are another source of feedback for teaching improvement. This may include standardized questionnaires that probe students about what they like the best and like the least, suggestions they have for the teaching process,

specific areas of concern. Additionally, lecturer can encourage students to form a class committee at the start of the semester that composed of students, to be in charge of collecting and providing feedback on the course and teaching performance from the student point of view. Students are often instructed during the last minutes of class to comment on a blank sheet of paper about the previous class or course in general, and to suggest whatever changes they feel would improve the course. This type of written comments can provide specific information for assessing the effectiveness of one teaching with an effort to make improvement when necessary.

At the Monash University Malaysia campus, there are also various methods of evaluation available to assess the teaching quality of lecturers that are developed and carried out by the Center for Higher Education Quality. The center, which can be found in <http://www.adm.monash.edu.au/cheq/>, leads and supports the development of quality assurance and improvement in all areas of Monash University's operations. The assessments are conducted by a surveying method called MonQueST. Student evaluation on the subject and teaching effectiveness is usually done at the conclusion of every unit. These feedback evaluations tell the lecturers about the teaching effectiveness and where improvements must be made to address the T&L problem areas in future tasks. Receiving this type of feedback keep one knowing what action and improvement needs to be made or what points need to be reviewed, reiterated and recapitulated so as to make the learning experience in classroom better. In addition, the feedback can be used to gauge the depth of student understanding of the course materials and then make the necessary corrective actions for the midcourse improvement.

Conclusions

Good teaching matters as effective teaching methods produce effective student learning. This would require adequate preparation and effective delivery in a motivated classroom environment. Adequate preparation requires thoughtful organizing and planning, not just the continuing evaluating/updating the material content but also contain learning activities that lead students to take part in dynamic and interactive exchanges in a class session. The challenge is for one to take full responsibility by actively doing everything in a teaching session not only to cause students to learn relevant materials confidently but also to help them to adapt to new changes by refreshing and updating their current level of knowledge and skills to fulfil new roles in their learning process.

This study supports the view that the T&L techniques that actively support student participation and involvement are necessary and important to enhance student learning. It also discussed the author's experience in the application of various T&L techniques in engineering education as a means of improving student learning. Personal experience and opinion, feedback evaluations, course surveys and comments were utilized to highlight the relationship between T&L in this paper.

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