Improvement of Delivery Methods in Teaching Materials Technology

R. HAMID, K. M. YUSOF, S.A. OSMAN AND R.A.O.K. RAHMAT
Department of Civil and Structural Engineering
Universiti Kebangsaan Malaysia
43600 UKM Bangi, Selangor Darul Ehsan
MALAYSIA
roszilah@eng.ukm.my

Abstract: - Since opting to Outcome Based Education method, the teaching of the subject Material Technology had resorted to problem-based learning method to achieve the outcomes attributed to this course. For the students to attain communication skill and life-long learning, problem-based learning is utilized to replace traditional lectures and laboratory works. Traditionally, lectures are given for 28 hours in a 42-hour per semester course and the rest allocated for laboratory works. In the newly endorsed method, the lecture hours are reduced to 14 hours and the rest is for presentation and seminars by the students. As for laboratory work, instead of doing individual experiment with individual report, the whole laboratory work for the semester is designed as components of a project. The results of the transition are: the students are more interested to attend class especially during presentation sessions where they provide high commitment; for a descriptive-form courses, such as Materials Technology, boring lectures can be made interesting by the students themselves presenting the materials with the lecturer's guide and as for the laboratory work, no more free riders and lack of understanding the relationship between individual experiment with the problem to be solved. The work load of the students is calculated using the definition of notional credit hour and the new improved delivery method for this course still maintain the three credit allocation.

Key-Words: - Problem-based learning, traditional method, transition, notional credit hour.

1 Introduction

Teachers of engineering field world wide have moved from traditional lecture based pedagogy which is a teacher-centred pedagogy to learner-centred pedagogy such as problem based learning strategy [1, 2] and building up classroom activities and assignments based on experiences that students bring to classroom while concept test and variable assessment tools carefully chosen to enhance metacognitive learning [3]. These efforts are triggered by different reasons, such as, fulfilling ABET (Accreditation Board for Engineering and Technology) criteria for accrediting engineering programs which requires that all engineering programs demonstrates that their graduates posses certain outcomes related to skills, knowledge and behaviours that the programs had promised to deliver [4], but for some engineering professors, they are just inspired to improve student learning since as early as in the 1960s [5].

At the Department of Civil and Structural Engineering (Dept. of C & S), Universiti Kebangsaan Malaysia (UKM), Outcome Based Education (OBE) was introduced in 2005 in line with the attempt by the Malaysian Engineering Accreditation Council (EAC) to apply for membership in Washington Accord which had mutual recognition agreement with ABET. The OBE was adopted by ABET in Engineering Criteria 2000 (EC2000). According to ABET [4], the EC2000 was a revolutionary approach to accreditation criteria. The focus was on what is learned rather than what is thought. It also called for continuous improvement process declared by the specific mission and goals of individual institutions and programs.

The course structure of Civil and Structural Engineering Program and Civil and Environmental Engineering Program at the Dept. of C & S are designed to fulfil the role of the civil engineer that is to plan, design and build. Materials Technology is a 3-creadit hour course offered to second year Civil Engineering students with 2/3 of the contact hour goes to lectures and 1/3 of it to laboratory works. As the course is divided into two distinct parts, i.e., lecture and laboratory works, this paper will deal with both the improvement of delivery methods in both course components. The objective of integrating laboratory works in course work is to assess the students understanding of the basic theories learned during lectures [6]. This course is classified as descriptive-form of subject compared to other courses in Civil Engineering where most of them are classified as problem-solving type of subjects. The Materials Technology lectures are synonym to boring and its laboratory works synonym to physical work followed by copied reports.

Below is the course structure for both programmes for second year students [7]:

Semester 1:

Humanity Course

KQ2133	Engineering Mathematics 3 (Differential Equation 1)
KH2123	Strength of Materials
KH2133	Fluids Mechanic for Civil Engineers
KH2173	Introduction to Environmental Engineering
KH2243	Engineering Surveying

Semester 2:

Co-curriculum

KQ2013	Engineering Statistic
KH2253	Geotechnical Engineering 1
KH2263	Materials Technology
KH2273	Structural Mechanic
ZT1022	Ethnic Relation

Three forth (75%) of the courses offered by the Civil and Structural Engineering Department (courses with first two alphabetical abbreviation code KH) for the first semester second year students have elements of laboratory work integrated into the courses, that is KH2133, KH2173 and KH2243. For the second semester, all three courses (100%) offered by the department (KH course) have elements of laboratory work that is KH2253, KH2263 and KH2273. Thus, it is inevitable that the method of handling the lab work is given proper deliberation not only because the marks of the laboratory report contribute to the final grade of the students (thus contribute to the achievement of program outcomes) but also the effectiveness of the laboratory work also reflects the role of the civil engineers. Furthermore, the significance of laboratory work will justify the expenditure of highly cost expertise and equipments at the Dept. of C & S laboratories which sum up to nearly 20 millions Malaysian Ringgit (£4 millions).

The objective of the course KH2263 Materials Technology is to introduce the physical and engineering properties of all categories of construction materials, via lecture, traditionally, and to do some related tests on concrete mix via laboratory work. Table 1 shows the learning outcomes matrix for KH2263. The course outcomes (CO) that are seen as contributed partially to the achievement of the program outcomes (PO) are identified. The program outcomes to be achieved through this course are PO1, ability to acquire and apply knowledge of basic science and engineering fundamentals; PO2, ability to communicate effectively, with technical and non technical community; PO6, ability to function effectively as an individual and in group with the capacity to be a leader, as well as, effective team member and PO9, ability to design and conduct experiments, as well as to analyze and interpret data. In order to achieve these outcomes, the delivery methods are designed and selected carefully.

Table 1 Learning Outcomes Matrix for KH2263

	Course Outcomes (CO)	*PO1*	*PO2*	*PO3*	*PO4*	*PO5*	*PO6*	*PO7*	*PO8*	*PO9*	*PO10*	*PO11*	*PO12*
1	To understand categories of materials used in civil engineering constructions.	3	2										
2	To understand the physical and mechanical properties of the construction material and their production processes.	3					2		1	2		1	
3	To have knowledge in new technology and new material used in construction industry.	2	2				2		1			1	

Description:

1 = CO contribute partially to PO without assessment,

2 = CO contribute partially to PO with formal assessment,

3 = CO contribute fully to PO with formal assessment.

PO for Dept of C & S:

PO1 - Ability to acquire and apply knowledge of basic science and civil engineering fundamentals.

PO2 – Ability to communicate effectively, with technical and non-technical community.

PO3 – Having technical competence in civil and structural engineering courses.

PO4 – Ability to undertake problem identification, formulation and solution using modern engineering tools.

PO5 – Ability to adopt system approach in the design of civil engineering infrastructures and to evaluate economic feasibility.

PO6 - Ability to function effectively as an individual and in group with the capacity to be a leader as well as effective team member.

PO7 – Having the understanding of the social, cultural, global and environmental responsibilities and ethics of a professional engineer and the need for sustainable development.

PO8 – Recognizing the need to undertake lifelong learning, and possessing/acquiring the capacity to do so.

PO9 – Ability to design and conduct experiments, as well as to analyze and interpret data.

PO10 – Ability to function on multi-disciplinary teams.

PO11 – Having knowledge of contemporary issues in particular those related to civil and structural engineering.

PO12 – Having the understanding of elements of construction project management, asset management, public policy, administration, business and entrepreneurship.

This paper will discuss a different approach by the team of lecturers in delivering and assessing this course. A part of the lectures are replaced with presentation and questions and answers (Q and A) session in seminars held. For the laboratory works, students are no longer given the Laboratory Manual, but they themselves have to find the testing methods suitable to solve the given problems / projects.

2 Traditional Lecture versus Learner Centred Approach

Instead of continuous 28 hours of lectures, half of the lectures materials are acquired by the students themselves and they present the materials in seminars. Students are divided into groups of five or six. Each group is given different topics on new construction materials or technology, which are also the content of the course. Students are required to prepare a report and presentation on the topic. The topics are given two weeks before the presentation session. Each group is given 20 minutes to present their topic in the seminar attended by registered students of the course and 10 minutes is allocated for Q and A session. Some of the topics not covered by the seminars are delivered through traditional lectures.

2.1 Assessment Method

During the seminar, each individual from the group presenting the topic has to present their part and during Q and A, anybody from the group can answer the questions. Assessment of the presentation is as shown in Table 2.

Table 2 Oral Presentation Evaluation Form

	Assessment	Details	Marks (0 – 100%)
1	Delivery (20%)	Appropriate dressing and self presentation, good posture.	
		Use of effective language and gesture, maintain eye contacts, speak loudly, clearly and with vocal variety (not monotonous).	
		Use of effective visual aids.	
		Appropriate timing.	
2	Content (60%)	Clear structure including introduction, content and conclusion.	
		Knowledge of subject matter and familiarity with the topic.	
		Clear presentation and logical	

		development of ideas.	
3	Questions and answers (20%)	Demonstrate good listening skills.	
		Ability to answer questions / defend ideas / give supporting examples.	

Students who ask questions during the Q & A session will also be given marks; 0, 1 or 2 depending on the relevancy and quality level of the questions. Presenters who answer the questions will also be given marks; 0, 1 or 2 depending on the accurateness of the answers. The lecturers acting as the assessing panel will review and comment accordingly at the end of the session. Since marks are given for these presentations, allocation of marks for final examination can be reduced and replaced with the seminar presentation marks.

2.2 Students Perception on the New Method

Short survey forms were distributed to students to investigate the relevancy of the seminars and their contributions in students learning process. Some of the questions are:

1. I felt bored and indifferent attending these seminars.
2. The seminars session had made me confident to ask questions.
3. I felt more confident talking in front of audience.
4. The seminar sessions had encouraged me to broaden my knowledge related to this course.
5. The seminar sessions had encouraged me to broaden my knowledge unrelated to this course.
6. The seminar session had helped me in information gathering methods.
7. Attending and preparing seminars are new to me.

The survey is valued based on scale 1 – 7, with 1 as *agreed completely* and 7 as *totally disagreed.* The results of the survey done on 99 students present on last day of class are as in Fig. 1 to Fig. 7.

Fig. 1 shows that majority of the students answered between 3 to 6, implying that they are not sure whether the seminars are boring or otherwise, thus, the need for improvement on how the seminars are handled.

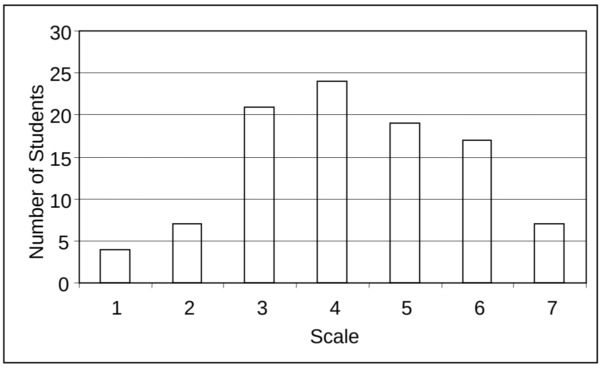

Fig. 1 Students response towards statement: I felt bored and indifferent attending these seminars

Fig. 2 shows that majority of the student agreed that the seminars had helped them in building their confidence to ask questions, showing that this method of learning is providing positive effect in that area of soft skill.

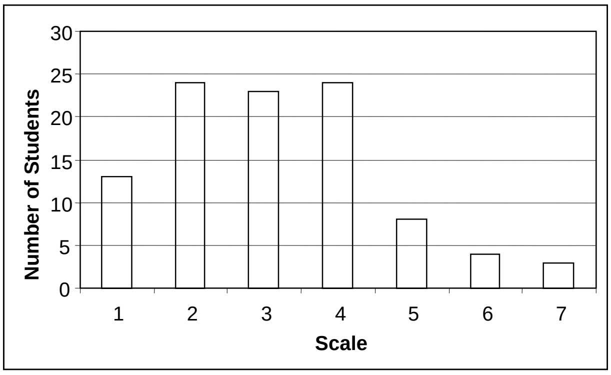

Fig 2 Students response towards statement: The seminar sessions had made me confident to ask questions

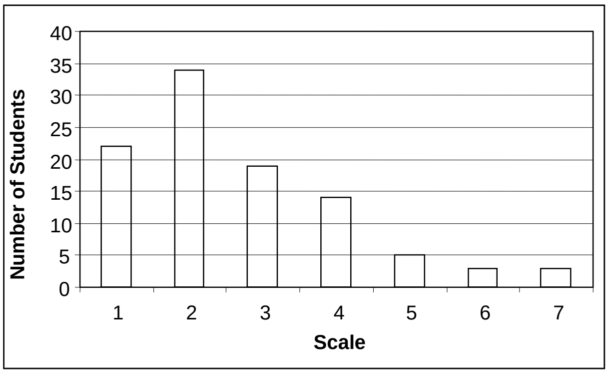

Fig. 3 Students response towards statement: I felt more confidence talking in front of audience.

Fig. 3 demonstrates that students had positive encouragement and confidence to speak in front of audience. Questions 1 to 3 were intended for assessing the communication skill of the students. Even though precise conclusion could not be made based on students' perceptions alone, the results of this survey can be used as bases for further improvement of the delivery method of this course.

Fig 4, 5 and 6 for questions 4, 5 and 6 are to identify the students attitude towards the needs to undertake life long learning, or at the least, how the preparation and discussion of the seminars had helped them improve their awareness on the needs for life long learning. Fig. 4, 5 and 6 show that majority of the students agreed that the seminars had helped them in attaining that particular skills.

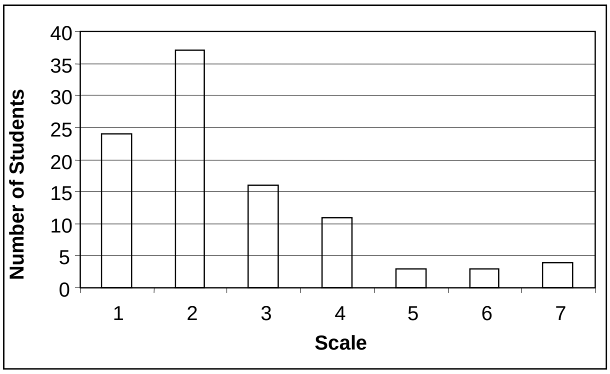

Fig. 4 Students response towards statement: The seminar sessions had encouraged me to broaden my knowledge related to this course.

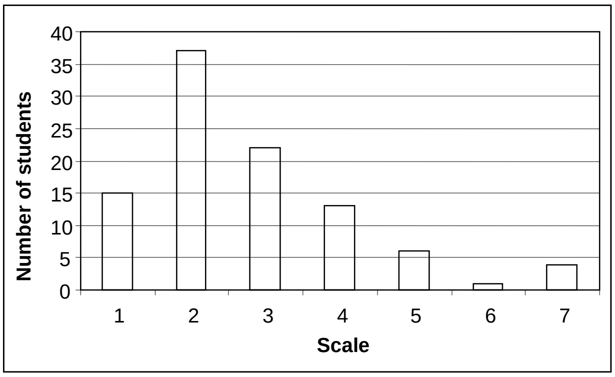

Fig. 5 Students response towards statement: The seminar sessions had encouraged me to broaden my knowledge unrelated to this course.

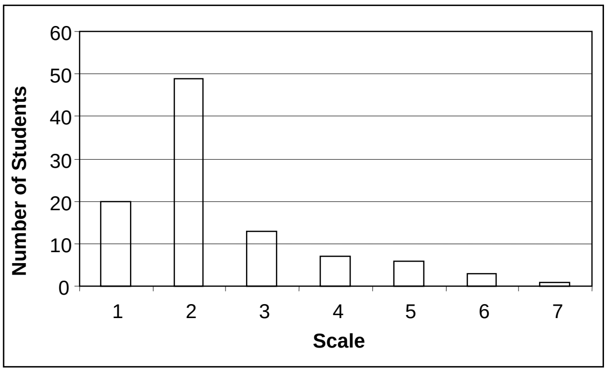

Fig. 6 The seminar sessions had helped me in information gathering methods.

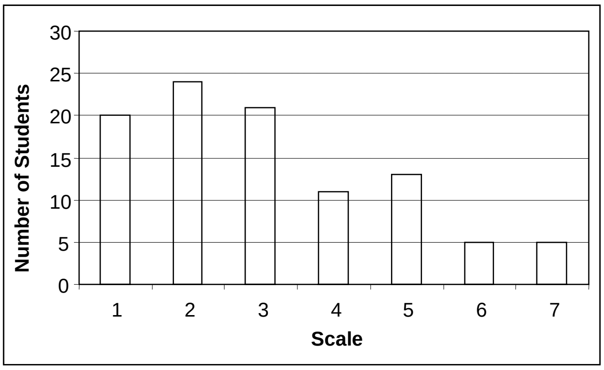

Fig. 7 Attending and preparing for seminars are new to me.

Fig. 7 shows that most students had never attended or given any seminars. It is important to expose the students with early development of communication skill and possession of capability to undertake life long learning, as early as second year, if not in first year, rather than to wait for presentation of their final year project to assess them with these skills.

3 Traditional Laboratory Work versus Problem Based Approach

The industry needs engineers that are not only well-versed in theories, but also are practical and understand practical situation. EAC following ABET had outlined one of the engineering accreditation criteria such that the program must deliver the students with the ability to design and conduct experiment, as well as analysing and interpreting the data [8]. Laboratory work has great potential to cultivate students' soft skills, such as:

1. Ability to work in a group.
2. Ability to select and utilize suitable equipment.
3. Ability to design experiment.

4. Ability to conduct experiment and analyze and interpret data.
5. Ability to develop model using the observed data.
6. Ability to understand the real practical work through experiment.
7. Awareness for the need to undertake life long learning.

3.1 Method of Handling Laboratory Work

Problem based learning is a subset of an active learning method. An active learning is a teaching and learning technique in class that involve the students with other activities aside from listening to lectures passively [9]. If adapted to laboratory work, the passive laboratory work learning method occur in the traditional way of handling them, where students are given the laboratory manual, without knowing why each experiment is run and what is the relationship between the experiments with real engineering problems. There are even students who become free riders and gain free marks without doing the experiments. On the other hand, students can actively do the laboratory work using the problem based method. Problem based method learning takes place by exposing the students with the engineering problem to be solved first [9]. Then only, the students can identify what's to be done to solve the problem. Next, students will learn/ find knowledge or information needed to solve the problem. Problem based learning can be adapted to Material Technology laboratory, as discussed below.

Generally, the traditional way of handling laboratory work for Materials Technology course is as shown in Table 3.

Table 3 Traditional way of handling laboratory work for Materials Technology course

Steps	*Handling Method*
1. Teaching and delivering	For the design of concrete mix, the lecturer explains what are the parameters needed for the design and mixing of concrete. Parameters such as the concrete strength, value of slump, water cement ratio are directly given to students and the students only have to do the practical work without finding / exploring themselves how the values of the parameter come about by experiments or from literature reviews.
2. Understanding and learning	After the teaching process, the students understand the content of the topic delivered by the lecturer.
3. Group distribution and students preparation 4.	Next, the students are divided into groups. Each student studied the laboratory manual.
5. Carrying out the experiment	At this stage, the students start to do the experiment. At this session, the students have to relate again the theory, terms and parameters given by the lecturer. During practical work, the lecturer/ demonstrator explains the objectives, theory, equipments, methodology and the expected results of the experiment.
6. Assessment of the laboratory work	After the practical work, the students prepare the report individually during the period specified, normally two weeks after the experiment is completed.

As we can see from Table 3, the traditional way of handling the laboratory work is a passive learning. The disadvantages of the traditional way of handling laboratory work explained above are:

1. Students are not clear on the relationship between the theory and the practical. An example will be the design parameters of the concrete mix, where the parameters needed in the design are priory given by the lecturer, thus the importance of obtaining the value through experiment is lost.
2. The reports produced by the students are low in quality and most students copied each other due to the content of the report is more on observation and the results of the experiments are already expected.

3. The ability of the students to solve the problem of the experiment is limited and students only depend on the content of the lectures without acquiring other references or information. The students ability to think is bounded and they are not given the opportunity to present their own and new ideas.

Due to the disadvantages perceived in the traditional way of handling the laboratory work in this course, the transition towards the problem based learning method as handled below is being opted to Material Technology laboratory work. Table 4 shows the problem-based learning implemented in Materials Technology laboratory work.

Table 4 Steps in applying problem-based learning method in laboratory work

Step		*Handling Method*
1.	Students are given a realistic problem	Students are given task to design a concrete mix for a specific structural element in certain construction project. The solutions require the students to determine the suitable grade of concrete, water cement ratio, slump and wet density of concrete and finally they have to calculate the weight of the concrete materials. Next, they have to prepare their own mix. After that, they have to test whether the concrete grade is equal to the grade designed. If the difference in 5%, the objective is accomplished.
2.	The students activate the previous knowledge and realize the new knowledge	To solve the problem, the students have to make certain what are the parameters needed to come up with the designed solution. The parameter such as the specific gravity of the sand and coarse aggregate has to be obtained through experiment.
3.	Responsibility and direction of learning is held by the students	The laboratory manuals and lab schedule is not prepared for the students. The students have to book the laboratory ahead to do the experiment (one particular day in a week in 14 weeks) to solve the problem.
4.	Demonstrator/ lecturer facilitate the learning process	Demonstrator/ lecturer are prepared to guide the students
5.	Information digging from various sources and analysis needed to solve the problem	The students have to find the standards for the experiments and they have to understand the laboratory procedures before doing the experiment.
6.	Student learn through team working	Good groups will divide works among them.
7.	Various knowledge and information is synthesized to come up with the solution	The values obtained are combined to solve the problem. If there's any value that is wrong / or unobtainable, the concrete mix can't be designed and the problem is not solved.
8.	The learning experience is assessed	A unique report for each group.

There are a few restraints and things to be given care to when opting for this method. The PBL methods required involvement of a quite large numbers of lecturers to handle and monitor the students during the duration of the project. Evaluation on the effectiveness of each group also should be done either through peer review or through observation during group discussions [10]. If the group is not effective, then it has to be dissolved rather than pursuing when it is already known than the result is not going to be of high-quality.

The 3-hour allocation for laboratory work previously is surely not enough for the students when opting for this problem-based method of handling lab work, thus the term notional credit hour is introduced to the calculation of actual load of the students per semester. The next section will discuss on the concern of this increase of students' workload per course.

3.2 Notional Learning Time

According to EAC Accreditation Manual [8], the loading of one credit hour (CH) or one credit means 40 hours of students learning time during one semester of 14 weeks. One notional value may be obtained from, including:

- One hour of lecture per week for a minimum of 14 weeks in a semester (not including examination or mid-term break).
- Two hours of laboratory or workshop for a minimum of 14 weeks in a semester (not including examination or mid-term break).
- Two hours per week for minimum of 14 weeks in a semester of problem based learning.
- One hour per week for a minimum of 14 weeks in a semester of presentation session
- Forty hours of activities per week for a minimum of 14 weeks in a semester involving other modes of delivery such as capstone, self-learning, e-learning modules, discovery learning, projects, etc.

The three credit allocation of Material Technology course is calculated by working out how many notional hours a student should engage in, in order to achieve competence in the knowledge and skills expected of him/her. A notional hour is not simply the `time-learning', but an indication of how learning was planned and managed. A notional hour, then, should include contact time (as listed by the EAC definition above) plus the independent learning time (e.g. preparing for presentations and lectures, library reading time, etc), assessment and any other task included in the course (e.g. research activities, group-work outside the contact hours, professional / occupational practice on which reflection would be based, and so on). Thus, to arrive to value one credit hour in a 14 week-semester, the notional credit hour allowed per semester is 40, that is, for 3 credit hours, the notional hour is 120. Table 5 shows the independent learning hour for each delivery method suggested in Guidelines on Standards by Ministry of Higher Education Malaysia (MOHE), Quality Assurance Division [11], for each contact hour.

Table 5 Independent learning hour allocated for each delivery method

Delivery Method	*Contact Hour*	*Learning Time*
Lecture	1	2
Attending Seminar	1	2
Lab Work (Practical)	1	0
Lab PBL	1	5
Presentation	1	5

Table 6 shows the calculation of notional credit hour for Material Technology course.

Table 6 Notional Credit Hour for KH2263

Week	*Lecture (hour)*	*Seminar (hour)*	*Lab (hour)*	*Presentation (hour)*	*Learning Time (hour)*	*Total (hour)*
1	2	0	0	0	4	6
2	2	0	2	0	9	13
3	2	0	2	0	9	13
4	2	0	2	0	9	13
5	2	0	0	0	4	6
6	2	0	2	0	9	13
7	2	0	0	0	4	6
8	0	0	2	0	5	7
9	0	2	0	0.5	6.5	9
10	0	2	0	0	4	6
11	0	2	2	0	9	13
12	0	2	0	0	4	6
13	0	2	0	0	4	6
14	0	2	0	0	4	6
Σ	14	12	12	0.5	84.5	123

Table 7 and 8 shows calculation of credit hour for lecture (previous allocation - 2) and laboratoty work (previous allocation – 1).

Table 7 Allocation of credit hour for each course component (Traditional Method)

Delivery Method	*Contact hour per week*	*Total hour per semester*	*Credit hour (Based on EAC definition)*
Lecture	2	28	2
Lab Work + Report writing	2	28	1
Total			3

Table 8 Allocation of credit hour for each course component (Improved Method) (Refer to Table 5 and 6)

Delivery Method	*Contact Hour*	*Learning Time*	*Total Notional Hour*	*Credit Hour*
Lecture	14	28	42	1.050
Attending seminar	12	24	36	0.900
Preparing for 0.5 hour of presentation	0.5	2.5	3	0.075
Total (Theory)				2.025
PBL for each experiment	0	30	30	0.750
Laboratory Work	12	0	12	0.300
Total (Laboratory Work)				1.050
Total				3.075

In the traditional method, the number of experiment to be conducted by students is 12, but in the newly improved method, the number is reduced to only six, all related to the problem given. As shown in Table 6, the workload, i.e. the number of credit is still maintained at three, with insignificant increase of 0.075.

4 Conclusion

The new opted delivery methods in teaching Materials Technology course had resulted in more students acknowledging interest in attending classes especially during presentation sessions where they provide high degree of commitment. The handling of lab work using PBL method can reduce the problem encountered in traditional way such as free riders and lack of understanding on the relationship between individual lab works with the problem to be solved.

References:

[1] Bower, K. C., Mays, T. W. and Miller, C. M., Small Group, Self-Directed Problem Based Learning Development in a Traditional Engineering Program, *34th. ASEE/IEEE Frontiers in Education Conference.* Oct. 20-23, 2004, pp. S 1B 16-21.

[2] Vandebona, U. and Attard, M. M. A Problem-based Learning Approach in a Civil Engineering curriculum. *World Transactions on Engineering and Technology Education,* Vol.1, No.1, 2002, pp. 99-102.

[3] Voss, S. E. and Ellis, G. W. Applying Learner-centered Pedagogy to an Engineering Circuit-Theory Class at Smith College. *32nd. ASEE/IEEE Frontiers in Education Conference.* Nov. 6-9, 2002, pp. 1-6.

[4] ABET. Criteria for accrediting Engineering Program. www.abet.org (23 Dec. 2008).

[5] Woods, D. R. 200 Years of Chemical Engineering Pedagogy: Pedagogy and Some Factors That Influence How We Facilitate Student Learning, http://cee.che.ufl.edu/AIChE_CEE_Woods_Pedagogy_Extended.pdf, (28 Dec.2008).

[6] Trident Technical College. Industrial and Engineering Technology Division: Student Handbook for Course and Laboratory Work, http://www.trident.edu/Student_handbook_for_Course_ and_Laboratory_Work_pdf, (12 Sept. 2005).

[7] *Undergraduate Guides Academic Session 2007-2008 Engineering Faculty,* Engineering Faculty, Universiti Kebangsaan Malaysia, 2007.

[8] EAC Accreditation Manual (2005). http://www.bem.org.my/eac/manual08-205/progress3.doc, (8 Jan. 2009).

[9] Yusof, K. M. and Hassan, S. A. H. S. Cooperative Learning and Problem-based Learning: An Introduction, Learning task Force, Universiti Teknologi Malaysia, 2005.

[10] Felder, R.M. and Brent, R. Effective Strategies for Cooperative Learning, *Journal Cooperative & Collaboration in College Teaching*, Vol.10, No.2, 2001, pp 69-75.

[11] Guidelines on Standards, Quality Assurance Division, Ministry of Higher Education, Malaysia, http://apps.emoe.gov.my/qad/standards.html (8 Jan. 2009)