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A Strategic Approach for Effective Teaching and Learning in Photonic Technology Course to Fulfill EAC and MQA Requirement

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Abstract: According to accreditation manual set by the Engineering Acreditation Council (EAC) has listed compulsory subjects which have been identified as core subject based on curriculum requirement in Academic Program (AP). This is also to comply requirement and recognition from. Thus, the department has implemented proactive steps by improving not only curriculum in AP but also at the lower stage which is at the subject itself. This step has been taken to match with the department's activities in order to achieve excellence by fully accredited for all offered AP. In the process of improving at the subject level, important elements such as subject delivery methods, syllabus contents, measurement and assessment methods, Generic Competency (GC) absorption and so on have been mainly focused on by considering input and comments obtained from stakeholders which consists of Industrial Advisory Panels, industrial representatives, alumni and students. This has been embedded into program curriculum. This study presents and discusses the improvement being applied on Photonics Technology (KC4013) subject which is part of the department's core subjects under Microelectronics program for undergraduates' students of Department of Electric, Electronic and System Engineering (EESE). It is also reporting effective teaching methods used in activities in increasing the understanding, students skills and competitive evaluation and CQI to guarantee the quality of the graduates students.

Key words: Core subject, improvement, teaching method, evaluation method, EAC, KKM

INTRODUCTION

Recent education has changed the direction from input based on time and contents to education based on objective which has focused on students' abilities in implementing something after they finished the learning process. In the other word, it is more focus on learning outcome which become students' target and destination. Hence, researchers need to plan forward and choose the best way to achieve the mission. In producing balance and excellent students, university curriculum need to be revised through the Country Education Philosophy, Education Acts which has been announced in year 1996, international requirement and education philosophy. Thus, university curriculum must have vision and mission, goals and objectives, learning outcomes, content of curriculum, curriculum content structures, teaching and learning strategy and assessment (Hamid, 2004). Among important rules in drafting new curriculum is redefined Programme Educational Objective (PEO) which reflecting the desired quality of the graduates' students and it has to be achieved after graduated for a few years. This objective also can increase the quality assurance in the teaching and learning process (Hamid, 2004). Besides, Program Outcomes (PO) need to be revised and measured by using specific measurement during the study program and after graduated (Abdullah *et al*., 2005). These program outcomes also can identify and evaluate the desired learning outcomes and also produce a balance and excellent graduates. Therefore, both learning objectives and program outcomes need to be prepared in drafting a new curriculum.

Hence in constructing integrated and relevant of PEO with career requirement, opinions from graduates and

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alumni also take into consideration through developed online survey. Thus, this study is presenting survey results based on each PEO statements.

PROGRAM OUTCOMES (PO)

Programme Outcomes (POs) are statements that describe what the students are expected to know or be able to do by the time of graduation. These POs are evaluated via Course Outcomes (COs) assessments in which there are statements that describe what the students are expected to know or be able to do upon completion of each course in the programme curriculum. The COs for Microelectronics engineering courses were formulated such that the COs and the devised POs are congruent and in turn support the PEOs and ultimately the mission and vision of both FEBE and UKM. Upon graduation, the graduates of Bachelor of Engineering with honours (Microelectronics Engineering) will have to demonstrate the following POs:

PO1: Ability to acquire and apply knowledge of basic science and engineering fundamentals
PO2: Ability to communicate effectively with technical and non-technical community
PO3: Having in-depth technical competence in microelectronics/computer and Communication/ electrical engineering courses
PO4: Ability to undertake problem identification, formulation and solution
PO5: Ability to utilize systems approach to design and evaluate operational performance
PO6: Ability to function effectively as an individual and in a group with the capacity to be a leader or manager as well as an 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, possessing/acquiring the capacity to do so and the need to have information management skill
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 the knowledge of contemporary issues in particular those related to microelectronics engineering
PO12: Ability to use techniques, skills and modern engineering tools necessary for engineering practice

EAC AND KKM REQUIREMENTS

According to Malaysia Qualified Agency (MQA) (Fahmi, 2006; Engineering Accreditation Council, 2007) among EAC and MQA requirements in accordance with MQA needs to be a priority for the industry are embedding and culticating OBE into teaching and learning system, performance evaluation based on the acquired/ measured outcomes:

- Curriculum of a subject under a program must be updated to always meet the needs of industry and technology development
- Students are exposed to ethics and professional responsibility to society and the environment as well as criteria for industrial needs. Students are exposed with professional etique and responsibility to community and environmental and also industry needs and critics
- Each program is always sensitive to change in the criticism raised by stakeholders and improvement actions should be taken immediately

Hence, the Department of Electric, Electronics and System Engineering (EESE) at the Faculty of Engineering and Built Environment, UKM has taken initiative to fulfill the requirement for three undergraduates Academic Programs (AP).

EESE offers three AP at undergraduate level namely Bachelor of Electric and Electronics Engineering (EE) program, Bachelor of Computer and Communication Engineering (CC) program and Bachelor of Microelectronic (μE) program. All these programs are under jurisdiction of Head of Department and assisted by a program coordinator for each offered AP. Each AP coordinator acts as chairperson of Curriculum review and Enhancement Program Committees (CREP) or also known as Committees of Program Curriculum Review (PCR) Committees which is based on definition and requirement of EAC while head of department is the chairperson of PCR at the department level. Therefore, a close collaboration among head of department, PA coodinators and all CREP/PCR committees and are responsible forming a world class and excellent AP.

The AP curriculum needs to fulfill the requirements of the EAC and Kurikulum PA yang dibentuk perlu memenuhi dua keperluan iaitu EAC and the Malaysian Qualifications Framework (MQF).

The objective of this study is to deliberate strategy to achieve excellence by presenting the program measures improvement to the department's courses especially KC is an important component that must be fulfilled prior to accreditation purposes. KC is the courses required for μE

students and KKKC4013 Photonics Technology has been chosen as a case study. The 1st step in the process of improvement is to benchmarking at the content level. Activities have been outlined to increase the understanding and students skill in learning process. Each student is required to prepare a report individual and group for each organized activities. At the end of this study is shown some ratings based of tests and questionnaires conducted to ensure the achievement of the learning objectives through the attainment of the PO. This subject has specifically measured achievement of some of the outcome program namely; PO1, PO3, PO6, PO9 and PO11. The study will decribe the strategy carries out based of three elements of the delivery, assessment and learning system to improve the effectiveness of this subject to meet the EAC and MQF requirements.

STRATEGY TOWARDS SUBJECT EXCELLENCE

The strategy is divided into 3 main parts namely delivery, assessment and system. Delivery refers to activities conducted during teaching process such as lectures, tutorials, embedded lab, lecture invitation from industrial and design project. Each activities need to evaluate to determine and assess the students performance. Among type assessments are test, quiz, presentation, report and so on. System refers to methods used to ensure student performance can be assessed through their true abilities. Benchmarking is also needed to ensure teaching syllabus is updated and aligned with prominent universities. Figure 1 shows a graphic diagram showing a kite that contains elements which are important

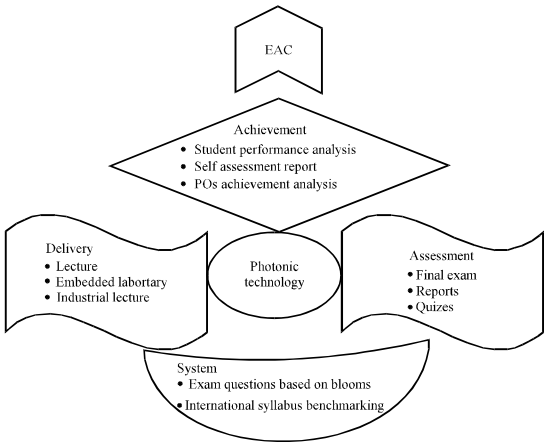

Fig. 1: Kite graphic shape presenting the importance of the delivery, assessment, system and performance measurement elements in ensuring the subject objectives are effectively achieved

in the strategy to strengthen the subject and every element is important in ensuring that the kite can fly well. To ensure that the taught subject meets the criteria of the EAC and MQF, several activities were undertaken to improve educational performance of students who are taking this subject. Among the activities carried out are listed:

- Benchmarking with prominent universities
- Embedded laboratory
- Lecture/talk from industrial
- Drafting question based on bloom and PO achievement
- Design project
- Analyse of student self assessment
- Analyse of performance
- Analyse PO achievement

Benchmarking with prominent universities: KKKC4013 subject is the fundamental subject for Analog and Digital Communication Theory. Detailed course content KKKC4013 are shown in Table 1 which includes the introduction of photonic technologies and applications today, geometrical optics, ray optics, electromagnetic optics, non-linear optics, optical waveguides, optical sources and applications in the display, storage and communication optics. Table 1 also shows the results obtained from the benchmarking process involving the comparison equivalent subject syllabus of prominent universities with the syllabus being used in UKM (Ge, 2007), School of Engineering Tohoku University in 2006 and dan Buku Panduan Prasiswazah UKM, Sesi Akademik in 2010/11. The universities involved are respectively from the National University of Athens and International University of Breman.

The results showed that the benchmark course syllabus Photonics Technology UKM have 50% similarity with the course syllabus Photonics Technology used in NTUA undergraduate level. IUB emphases more on the application of photonics in optical communication systems, moreover the allocation of sub-topics is too general compared to the UKM subtopic is more specific and reflects to the syllabus taught. In general, researchers can conclude that the syllabus taught at UKM is equivalent to the syllabus taught at the foreign university. However, according to the concept and practice of Continuous Quality Improvement (CQI), the Department needs to revise syllabus, benchmarked and updated each year by taking into account technological developments. The conclusion is both of the universities have emphasized the application of photonics technology itself rather than the basic physics elements. In UKM, this

Table 1: Benchmarking of KKKC4013 syllabus with equivalent subject offered in Greece and Japan

Universiti Kebangsaan Malaysia	National Technical University of Athens	International University Bremen
Photonic technology	Photonic technology	Photonic and optical communication
Bachelor program	Bachelor program	Bachelor program
Introduction and photonic technology scenario today	Photonic components used in telecommunication systems	Introduction to photonics and optical communication
Optic geometry, characteristic, application, limitation and optical measurement	Basic theory of operation and characteristics of photonic components and their assembly into fiber transmission systems	Review of optics
Optic beam, Gaussian beam and Gaussian Hermite, application and limitation	Passive components: single-mode, multi-mode and polarization maintaining optical fibers, optical couplers/splitters, optical isolators and optical filters	Optical waveguides
Optic wave, interference and interferometer	Active components: semiconductor lasers, optical amplifiers, optical modulators and photo detectors	Optical fibers
Optic electromagnetic, polarization, birefringence	Introduction to digital and analog fiber transmission systems	Optical sources and transmitters
Optic non-linear, electro-optic and application	Optical signal distortion	Optical detectors and receivers
Optic guidance, optical coupling and coupling devices	High speed Time-Domain Multiplexing (TDM) transmission systems	Light wave systems
Photon and mass reaction, optical quantum, luminence and optical amplifier technology, optical oscillating cavity	Wavelength Division Multiplexing (WDM) transmission systems	Optical devices/Optical amplifiers
Laser technology; solid state laser and gas laser and the application.	All-optical logic circuits and ultra-high speed optical signal processing	Optical MUX and DEMUX
Photon in semiconductor, LED and semiconductor laser (LD), photodetector		Systems design
Display device; CCD and LCD		
Optical compact disk, CD, VCD, DVD and blue technology		
Advanced optical material and application		

application is included as a whole and not focus simply on communication system due to there is another subject discusses in detail the application of photonic technologies in the communications system in the KT4043 subject. Furthermore Photonics Technology subject is offered to students of the microelectronic engineering program only.

Researchers implementing the physically benchmarking on the program level while the virtual benchmarking is done at course level. Here, every course offered by the department must have at least 2-3 benchmarking from the well established university to ensure the syllabus is up to date and fulfill the current technology demand. Additional, the department also has organized several meeting with industrial (at least once in semester) to look over the syllabus in all related courses to ensure the syllabus, skills and tools are fitted with what are required by the current industrial.

Embedded laboratory: The aim of this activity is to expose students to the world of research in the field of Photonic Technology. The study will be highlighted the exposure of the students to relate theory taught in lectures to practical research conducted in the laboratory. In this course, students will be exposed to fabrication techniques such as optical device by hand (Ab-Rahman *et al*., 2011) which is a new device in the Photonics Technology. Two devices namely Splitter and demultiplexes are fabricated using green technology where both devices are key components used in broadband WDM. Installation of these devices is also in the POF-WDM network which is also shown along with the application that is able to contribute to this technology. Students are required to submit learning report. The result of the program can be assessed from these activities were PO6. This study discussed examples of the laboratory setting that exposes students to a green optical device fabrication techniques or environmentally friendly.

Lecture from industrial: Researchers have invited an engineer from the industry to give lectures to students on the use technological knowledge in the production of photonic devices. He stressed that the design elements and tools used to design a new optical devices. At the end of the workshop, students are required to use the knowledge gained in a design project which requires them to design a new optical device. Student needs to submit individual reports on the subject of loading new components in this activity. This study discussed a report prepared for the technical talks organized.

Formulation of questions based on bloom and PO achievement level: EESE has also taken initiatives to strengthen the examination questions by formulating questions based on Bloom's Taxonomy level of the Bloom's Taxonomy of introducing Revision Form which EESE Bloom has set a level by student's education level. Six types of Bloom which is categories into three groups namely; group 1 (Level 1 and 2), group 2 (Level 3) and group 3 (Level 4-6). Student level (year 1-4) will be divided based on group percentages. For instance for this subject (KKKC4013) is for year 4 so the exam questions must include 0-10% from group 1 level, 15% from group 2 and 75% from group 3. Therefore, the drafted exam questions with an appropriate level of bloom which is aligned with the development of student learning. Bloom taxonomy form for Photonics Technology KC4013 subject can be found in the files of the course.

Analyse of student self assessment: Students are given the opportunity to assess self performance for each course at the beginning and end of each semester. Every Course Outcomes (CO) will be assessed on 1-5 Likert scale. Assessment 1 shows that students do not have any knowledge regarding the specific courses and assessment 4 shows the students know the depth of a learning outcome. Figure 2a and b shows the self-assessment of students for this course at the beginning and end of the semester separately. Through analysis of the self-assessment undertaken to enable evaluation of effectiveness teaching can be done. The results obtained can also be used as an evaluation methodology that was used by a lecturer through the students' perception to a matter which is referred as the Course learning Outcomes (CO). There are 5 scales of assessment as following:

- Has no direct knowledge of the matters
- Having little knowledge of the matters
- A satisfactory level of understanding about the matters
- Good level of understanding about the matters
- Excellent level of understanding about the matters

Figure 3 shows the comparative analysis of the self-assessment for students before and after lecture. For the CO1 in general, students still feel that their knowledge of these topics is still shallow even though 35% gave satisfactory and good on the topic. After 14 weeks, the percentage of satisfactory was increased to 10, 80% good and 10% excellent for the knowledge they gained. Similarly, the attainment of other course outcomes (after 14 weeks) namely CO2 is 80%, CO3 (75%) and CO4 (80%). Although, the method of these analysis is indirect but it

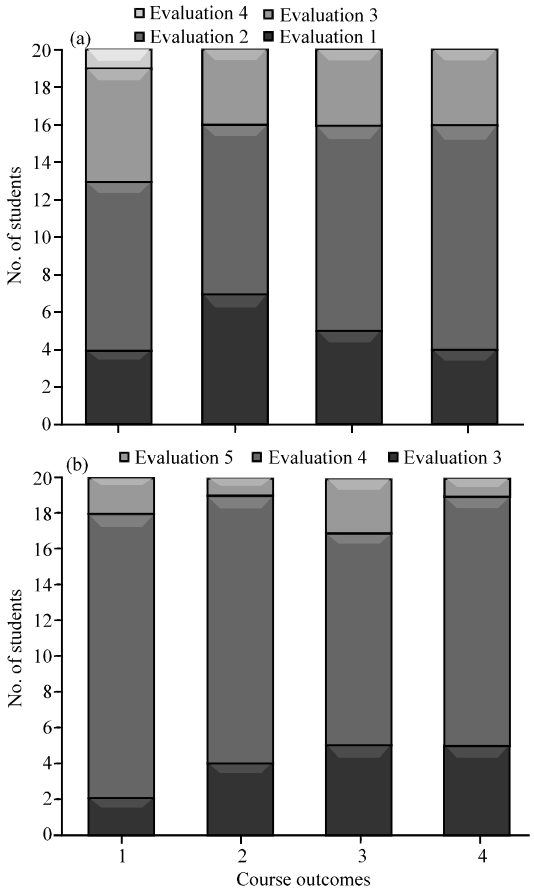

Fig. 2: Analyse of student self assessment based on results of course outcomes for photonics technology subject; a) First week of the semester; b) Last week of the semester

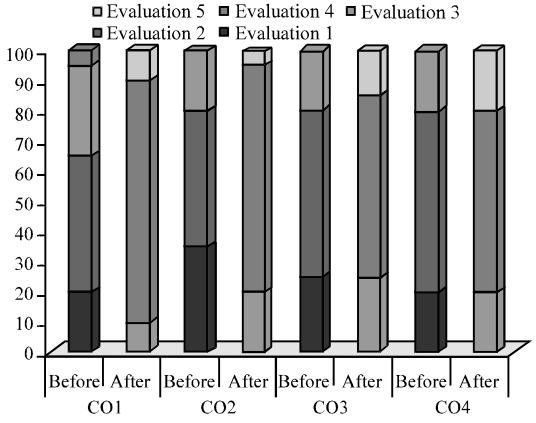

Fig. 3: Comparative analysis of student self assessment before and after lectures

gives a clear picture about the effectiveness of the presentation by the lecturer. With the understanding that

a high percentage of each CO showed the students were prepared to sit for the examinations which will be held at the end of the semester.

Analysis of performance: Overall student achievement can be reflected through their results as shown in Fig. 4. The final and mid examinations comprises of highest percentage (60%) while 40% for quizzes and other activities which are presented in report form.

Based on the overall performance of students, it is found that a total of 7 students achieved excellent grade (A and A-) while 12 obtained a good grade (B+, B and B-) while only about 1 student obtained a C+ grade. From the performance and the student self-assessment showed that this course has been taught effectively while activities help students performed much better in understanding the syllabus in this subject.

Analysis of PO achievement: This subject measures 5 PO namely; PO1, PO3, PO6, PO9 and PO11. PO measurement is based on assessment conducted in examinations, assignments and also reports of the organized activities. Rating scale ranges from 1-5 with 1 being the lowest performance and 5% an outstanding achievement by 3 at the minimum level of achievement. From the analysis carried out as shown in Fig. 5, it is shown that the PO3 did not reach its target. Therefore, action needs to be carried out immediately to solve the problem. Figure 5 shows the PO attainment by the students.

Continuous quality improvement: Under OBE system, any PEO and PO which are not achieved will refer to the courses taught and CO will be revised. Thereafter the new strategy will be implemented to enhance and improve the PO and the PEO. CQI process is shown in Fig. 6. Referring to the CQI flowchart any discrepancies between the achievement of PEO or PO must have to go down and look at the course level. The course objective and the delivery (method or teaching) need to be improved and strategized. Methods of teaching or delivery refer to the activities organized to enhance students' understanding and skills for a CO and eventually contribute to the achievement of the PO and the PEO.

Embedded laboratory: Figure 7 shows examples of the laboratory setting that exposes students to a green optical device fabrication techniques or environmentally friendly. One post-graduate student has been put in charge to assist the students in preparing apparatus as well as demonstrating the technique fabrication. With the

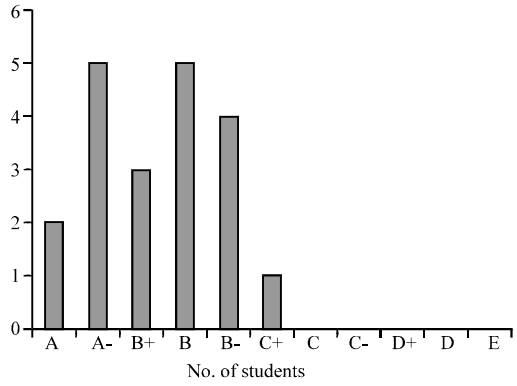

Fig. 4: Overall student performances in Gaussian pattern for photonics technology subject

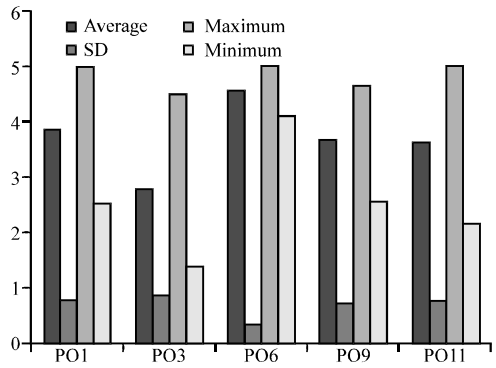

Fig. 5: Analysis learning outcome performances

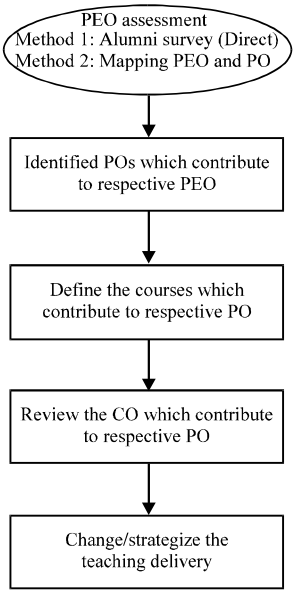

Fig. 6: Flow chart of CQI of the system for teaching and learning of the program

activity the students are exposed to the research activities and at the same time to motivate them to further the study in the future after they have completing the undergraduate study.

Lecture from industrial: Figure 8 shows a report prepared for the technical talks organized. The lecturer and engineer are co-operated to explain the topic and the same time correlating between the industry and academic knowledge. This is very important to eliminate the gap between the university and industry.

Design project: Through the knowledge gained from the lectures and talk and activities involved by the industrial,

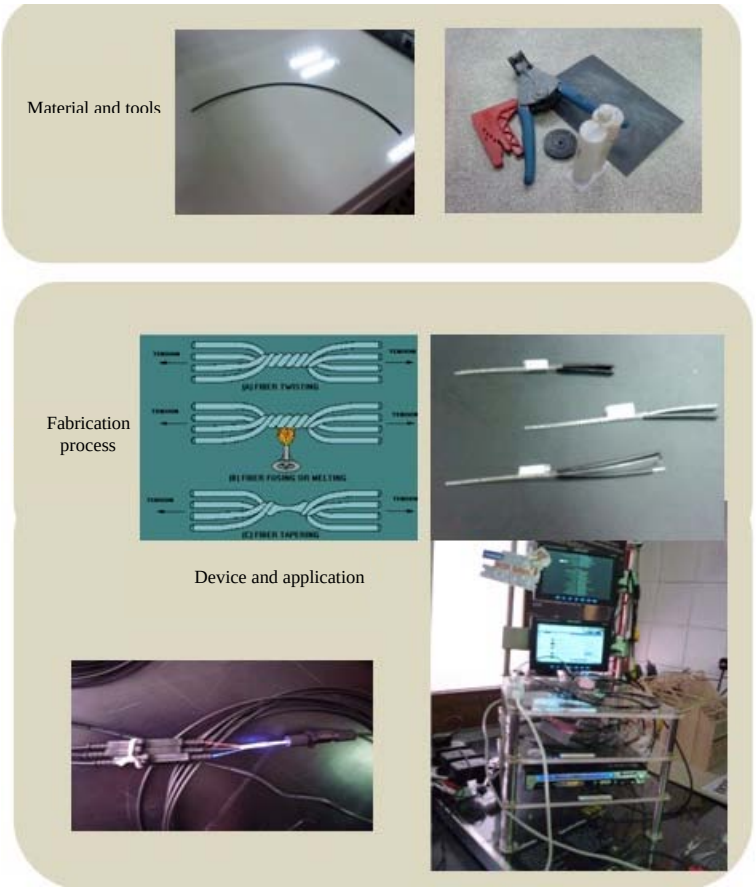

Fig. 7: Embedded laboratory report which expose student about latest issue and development of new technologies. The activity entitled Green Photonics Technology

The speaker made an introduction on OptiBPM

The speaker explained the function of OptiBPM

Fig. 8: Continue

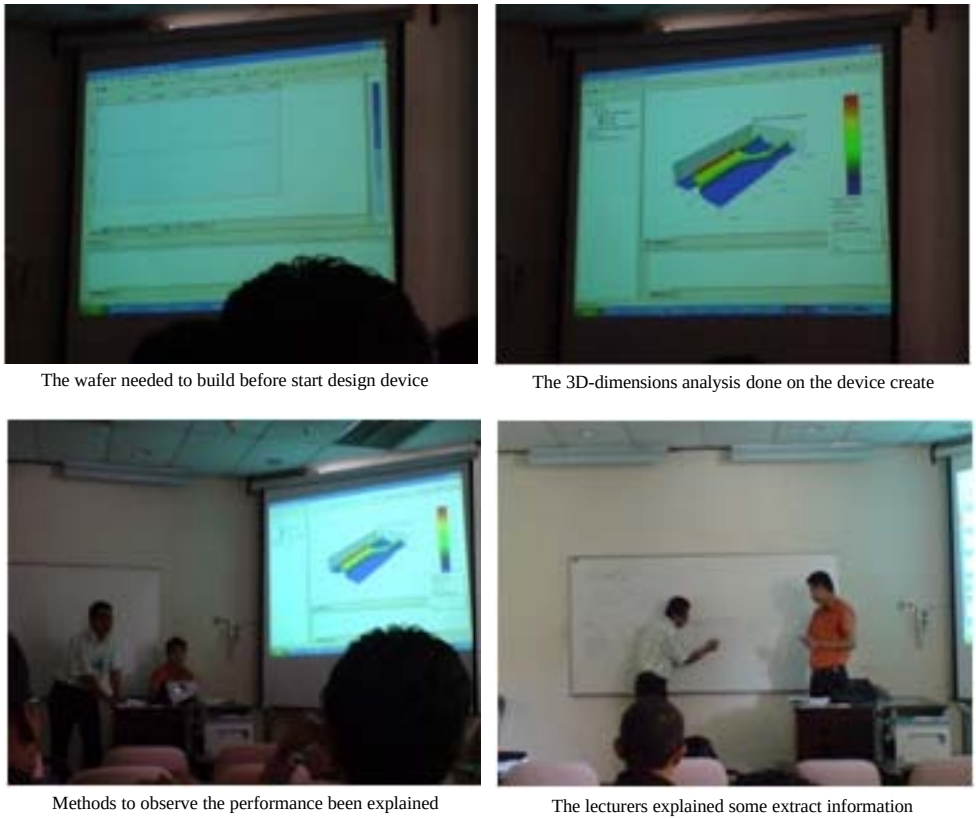

Fig. 8: Report of technical talk from industrial explaining tool used for designing and reviewing new optical device

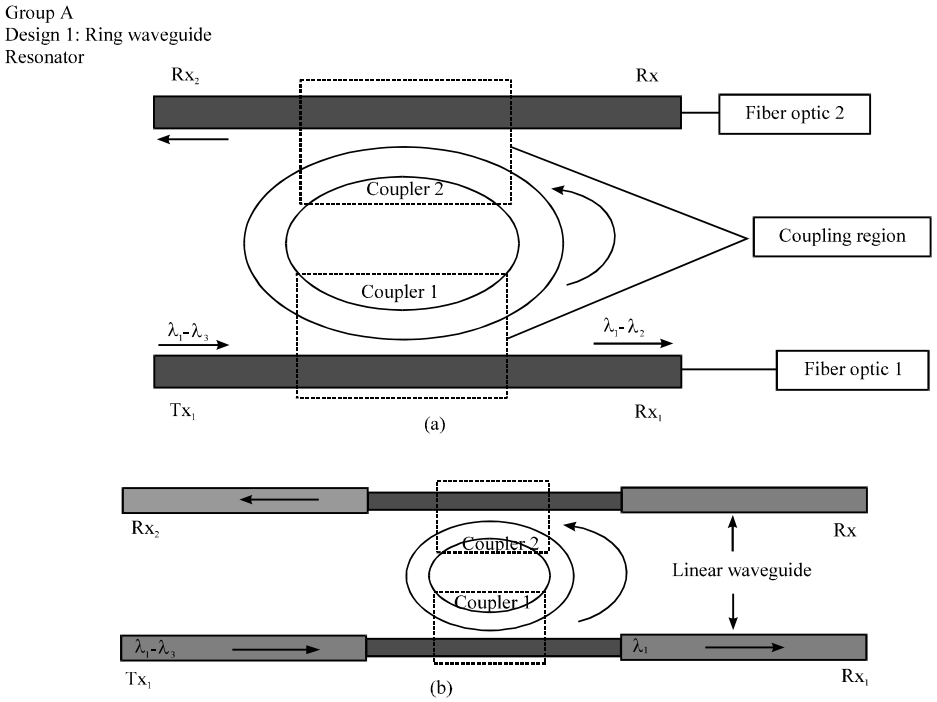

Fig. 9: a) Ring resonator waveguide; b) Application in optical filter

sudents can apply the knowledge in their design project. Students are required to design a new optical device and suggest how the design applied in the application of optical communications systems. Students are also provided a research laboratory to carry out simulations of the proposed device. Trough this project, students' creativity can be polished and can expose students in the real research such as in R&D. These activities are measured for PO9 learning outcome. Figure 9 shows a student design project to develop a new optical device called Ring waveguide resonator. The proposed design of this device is unique as it was first reported. This has proved the ability and the understanding of the student.

CONCLUSION

Learning is not just happening in the lecture only and it is important in developing a more effective form of presentation to motivate students. Several activities were organized to improve student understanding such as embedded laboratory, lectures and talk by the industrial representative and design projects. To achieve the right evaluation and reach the standard, examination questions are formulated based on the achievement of bloom taxonomy. Moreover, the course syllabus has been benchmarking with two leading university. This study reports the applied strategy is to ensure teaching and learning are effective and fulfilled the requirements of the EAC and the MQA.

Teaching and learning activities will become more lively and effective when integrated with the research element together with the taught syllabus. The contribution of this research results by the university is important to ensure that taught topics are updated and advanced. Therefore, research is an important element in improving the effectiveness of subject teaching.

APPENDIX

Universiti Kebangsaan Malaysia
Jabatan Kejuruteraan Elektrik, Elektronik dan Sistem
(Borang Semakan Taksonomi Bloom)
Semester 1, Sesi 2008-2009

Kod kursus	KKKC4013
Tajuk kursus	Teknologi fotonik
Penyelaras/Pensyarah Kursus	Dr. Mohd Syuhaimi Abd. Rahman

Markah						
	Lower level			Upper level		
No. Soalan	Pengetahuan knowledge	Pemahaman comprehension	Aplikasi application	Analisis analysis	Sintesis synthesis	Penilaian evaluation
Part A						
1				5		
2			2		3	
3			4	6		
4				10		
5						10
6						20
Part B						
1a					6	
1b			4			
1c				6		
1d					4	
2a					4	
2b					4	
2c			8		4	

Jumlah Markah						
Markah Penuh	100					
Markah	0	0	18	27	25	30
Peratusan	0.00	0.00	18.00	27.00	25.00	30.00

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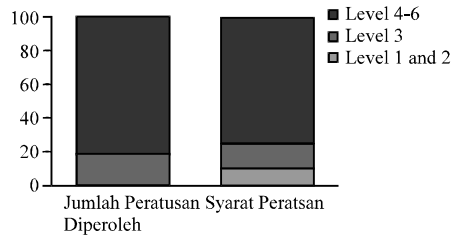
Analisis markah

Level	Jumlah Peratussan Diperoleh	Syarat peratusan (%)
Level 1 and 2	0.00	0-10
Level 3	18.00	15
Level 4-6	82.00	75

Keputusan	Memenuhi Keperluan Taksonomi Bloom?
Ya	



Appedix: Sample of bloom taxonomy form used for monitoring the quality of formulated exam questions

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