OUTCOME-BASED JOINT GRADUATE PROGRAMME: BUILDING CAPACITY IN ENVIRONMENTAL ENGINEERING

A. A. Aziz[1], M. J. Megat Mohd Noor[1] and R. Hashim[2]
[1]Department of Civil Engineering, Universiti Putra Malaysia, Serdang, Selangor, Malaysia
[2]Department of Civil Engineering, University of Malaya, Kuala Lumpur, Malaysia
E-mail: azlan@eng.upm.edu.my

ABSTRACT

A consortium of four major universities consisting of Universiti Malaya, Universiti Kebangsaan Malaysia, Universiti Putra Malaysia and Universiti Teknologi Malaysia was established and is known as the Malaysian University Consortium on Environment and Development – Industrial and Urban Areas (MUCED-I&UA[1]). The prime aim of the consortium is to build capacity via the establishment of a multidisciplinary graduate programme related to Environment and Development to ensure sustainable development. Transfer credit mechanism between the four participating universities ensures flexibility within the programme. Engineering, sciences and management as well as elements of the social sciences are integrated to produce a multidisciplinary programme. The MUCED-I&UA engineering programmes related to environment as currently envisaged is somewhat similar to that found at Technical University of Denmark (DTU). MUCED-I&UA further embarked on enhancing existing graduate courses and creating new ones at the four universities. A total of twelve courses were jointly developed and/or enhanced and 18 case studies to be used in the teaching process were documented. These courses were developed together with the Danish counterparts, mainly from DTU, Aalborg University (AAU) and Roskilde University (RUC). Involvement of various stakeholders related to industrial and urban development was also sought when developing the course modules. The consortium introduced Project Oriented Problem Based Learning (POPBL) within the courses as part of the overall outcome-based assessment. The courses are not organized under themes as practiced in AAU and RUC. The developed and/or enhanced courses are organized as a separate entity although continuity, multi- and inter-disciplinary approaches to problem solving are considered. These courses are assessed separately. The POPBL approach is however expected from the project work undertaken by all students. Students may either draw the knowledge from the attended courses or seek additional knowledge separately to solve the problem. This paper deliberates the experiences of the joint effort of the consortium members in capacity building and formulating the programme. The details in implementing one course of the engineering programme in respect to co-teaching, and its evaluation by the students are discussed.

Keywords: *Outcome-based Environmental Education, Programme and Course Development, Project Oriented Problem Based Learning*

INTRODUCTION

Most graduate schools in Malaysia were set up in the 1980s on the advice of academic consultants from the UK/USA/Australia/Canada or by local academics educated in the aforementioned countries. In general, it is fair to say that most taught graduate engineering and applied science (i.e. technology) programmes in Malaysia are replicas or hybrids of the typical UK and/or USA programme. This is hardly surprising, as there is a tendency to follow patterns of curricula, organizational and committee structure, laboratory design and equipment, etc. familiar to them.

A grasp of fundamental and engineering science course applies to engineering programmes everywhere but some difference in emphasis may be desirable. The cultural background of students and deficiencies in the selection process even at the graduate level may require more time to be devoted to general education, especially in the social sciences, humanities and the use of the English language. It should be noted that available reference material are in English and to a large extent are still for Western and industrialised engineering requirements. However, technological development is now so rapid that no one really can foresee what is going to happen in the future, still less prepare students specifically for the techniques that will be used. Attention is also drawn to a serious defect in the selection and education for the profession. At least in Malaysia, students are selected for entry to graduate engineering programmes mainly or solely on the basis of the candidates' examination results at the undergraduate level. A candidate's real aptitude for an engineering career

[1] A list of acronyms used in this paper is presented in Appendix A.

cannot be fully assessed from his interest and performance at an age (21-23) when he may have had little direct experience of what engineering or the profession is about. In fact in Malaysia, he would have had to decide which subjects to concentrate on at high school several years earlier still. This method of selection has obvious shortcomings and leads to many misfits among students. Alas, national priorities and urgencies dictate that some streamlining is desirable. Until recently in Malaysia, at the undergraduate engineering level, there has been an attempt to rectify and to include a more broad-based approach to the foregoing issues [1]. Hence, the selection for further graduate training should be based on performance in work as well as on academic ability.

In most of the graduate courses, much more attention is given to the analyses of engineering problems rather than to synthesis. What is really needed is to develop the students' ability to think clearly, to express unfamiliar problems in their essential elements and to encourage their powers of synthesis and imagination. It is only too easy to tell the students, to pump information into them and not so easy to bring them out, to encourage them to contribute to the educational process. Real engineering, however, contains at least as much practice as theory, and success in it also depends on the art of dealing with and getting on with people, and on an understanding of the socio-economic and environmental factors that are hardly touched on in most engineering or applied science courses [2]. The environmental impact of engineering work needs to be given more emphasis than it currently receives. The effect of rapid development on the physical environment can mean irretrievable damage, which the country may later come to regret bitterly. Under the pressures of economic survival and growth, developing countries in general are less caring for their environmental heritage – e.g. their forests, fauna, marine life, clean air and unpolluted waters and soil - than the developed countries have become.

To summarise, tertiary teaching institutions ration the supply of professional people such as engineers through their teaching and examination system and the standards they set. Engineering schools take the selection process further mainly on academic ability of a theoretical type and on analytical processes. Every experienced engineering teacher is uncomfortably aware of students who, after failing miserably to pass the academic screening process, became highly successful engineers in later life or become successful in other careers. How students are taught appears to be more important than what they are taught**.** Thus, most engineering courses could benefit from fewer straight lectures and more two-way activity; like discussion classes and tutorial groups, assignments in which the students have to find out things for themselves, design projects which really tax the imagination, more experimental work and strong links throughout with the life of the community and its engineering problems. Graduates of the programme need to be especially alert to the dangers associated with their work. The philosophy of sustainable development should run right through an environmental engineering programme, not just be added to an existing programme as yet another course. Ideally, it should permeate the outlook of every teacher in the programme but it has to be recognized that it takes a long time for this to be fully realised. The potential of a new system to improve instruction depends strongly on how well engineering teachers understand it and appreciate the extent to which their involvement in it is crucial.

A strategy for interacting programme level and course level activities when designing an instructional programme to directly address the educational objectives and to encompass certain specified outcomes has been proposed by Felder and Brent [3]. More detailed discussions on outcome-based curricular development are also given by Besterfield-Sacre et al [4]. In the curricular development stage, instructional techniques to effectively prepare students to achieve the outcomes by the time they graduate can be included. These techniques, other than the usual traditional instructional 'sage-on-stage' methods, including PBL and Cooperative Learning (CL) have been identified and described by Felder et al [5], Edens [6] and Johnson et al [7].

Given the foregoing discussion, a brave attempt is made in Malaysia to point to new directions in the environmental education of the professions at the graduate level. MUCED-I&UA was formally operational in August 2000 although work to initiate a collaborative project to build capacity in the field of environment had started in the mid-nineties. The project to formulate a common programme and courses at postgraduate level between four participating Malaysian universities i.e. UM, UKM, UPM and UTM was proposed. The project is geared towards the improvement and integration of education and research in environmental management and technology in urban areas and industry. Key priorities are the promotion of multidisciplinary approaches in environmental studies and problem/project-based learning. The formal structure adopted is a first collaborative effort amongst the four participating Malaysian universities in the consortium. In such an endeavour, MUCED-I&UA is aided by the wealth of experience to be found within their Danish counterparts in DUCED-I&UA.

CAPACITY BUILDING AND PROGRAMME DEVELOPMENT

It would have been convenient to adopt wholesale a similar programme as found elsewhere but existing barriers and adaptation to local needs always demand a fresh and inventive approach by those concerned with this work. Institutional peculiarities and policies, which are normally the major stumbling block to the success of the collaborative effort, needed to be streamlined to ensure a workable solution. Thus, at the outset, the strong support from the vice-chancellors of the four universities was sought. The seal of approval to work together was obtained through an agreement signed by the vice chancellors of the four universities. The agreement gave the project collaborators the required assurance to produce an acceptable programme and several common courses. The Project Steering Committee (PSC) and the Project Management Committee (PMC) formed provided the initial impetus to undertake the work and to place the foundation for the collaborative effort.

Malaysian universities are offering programmes in all fields relevant to sustainable environmental management. Each of the participating university has a postgraduate programme anchored to different disciplines; from engineering and technology to economics. However, the teaching found in these programmmes is by discipline whereas sustainable development requires multidisciplinary skills and interdisciplinary approaches. It was anticipated that forging ahead with a new common programme would create a delay. Given that existing programmes are already in place, it was decided that twelve selected courses be either developed or enhanced in the four universities. This path was taken to hasten the implementation of the project. It was also thought that having a set of courses agreed upon by the participating universities would provide a clearer platform for a common multidisciplinary programme. The courses developed are incorporated into existing master programmes in the four universities. The involvement of other stakeholders from industry and NGOs, such as Alam Flora, Indah Water Konsortium (IWK) and WWF, were emphasised. Their input ensured that the courses developed take cognizance of the current needs of the industry and society. The twelve courses selected are:

Core Courses
1. Environmental Management
2. Water pollution Control
3. Environmental Monitoring and Assessment
4. Solid and Hazardous Waste Management

Elective courses
1. Air Pollution
2. Cleaner Technology
3. Environmental Economics
4. Environmental Geotechniques
5. Environmental Health and Safety
6. Environmental Impact Assessment
7. Environmental Modeling
8. Environmental Technology and Design

As listed above, four of these courses are core and the rest are electives. A discussion between representatives from the four universities on the appropriate courses to be developed led to a consensus on the definition of core and elective courses. Core courses do not mean compulsory attendance at each participating university but rather developed from all four consortium universities. Elective courses need only have inputs from at least two participating universities. In addition, a core course is considered as having a more multidisciplinary content whereas the electives as having contents between the two extreme disciplines i.e. management science or applied science/engineering. Despite all this, the core courses could also be an elective in an existing programme, as the existing programmes stretch from environmental management to environmental engineering. As an example, the Solid and Hazardous Waste Management is an equivalent elective course in the M. S. Water Engineering programme at UPM whereas the equivalent to Environmental Technology and Design is a core subject [8]. In light of the preceding discussion, the educational objective of the MUCED-I&UA Environmental Programme is broadly formulated as "providing students with proficiency in both the art and science of the environment". Within the context of the broad objectives, further refinement to suit the individual existing programmes is thus accommodated. One such example has been indicated in Megat Johari et al [8].

Courses offered at the respective universities are considered as equivalent to the MUCED-I&UA courses if at least 80% of the content is found to be the same. This criterion for recognition of the courses was agreed among the four universities and thus facilitated the credit transfer mechanism between the consortium universities. The mechanism allows students registered at a particular university to undertake some courses at the other participating universities and carry the credit for graduation. As such there would be cross-fertilisation and also the sharing of resources among consortium members. Instead of being competitors, the consortium acts as a single unified body that provides the opportunity for students to obtain their environmental education at its optimum condition and for the realisation of the multidisciplinary approach. This is possible since the consortium comprises expertise of various disciplines ranging from the arts and social sciences to engineering. As for the engineering programmes, the incorporation of non-engineering courses enhances the overall skills and competencies of its graduates as in reality problem solving do involve non-engineering solutions.

All the identified courses were integrated into the regular course schedule of participating MUCED-I&UA universities by the November Semester of 2002. Teaching and case study materials for the courses were developed in the form of a module (teaching manual) by June 2002. The approach taken to develop the courses was very much dependent on the members involved. Syllabi were enhanced or developed accordingly with agreement between the involved parties. The methodology of teaching agreed was to include the PBL wherever possible. Case study preparations if not readily available were augmented via funds made available for the purpose. Given that PBL and case study preparation may be new concepts to some of the academics involved in this exercise, two course development workshops to orientate them towards a concerted goal were conducted. Course developers were appropriately instructed in the rudiments of module writing. Formats of course materials, guidelines on typing and research assistance towards the preparation of the course were agreed upon. Honorarium to course developers are provided for and links for mutual benefits amongst the team members are cemented. Direct involvement in formulating the course contents by representatives from the involved universities not only created the "social bond" but also extended their involvement in other academic field such as external examination, research collaboration and consultancy endeavours. The workshops were also attended by their Danish counterparts from DUCED-I&UA whose contributions were much appreciated.

Further inputs from their Danish counterparts were solicited through visits of course developers to Danish universities to study the content and conduct of related courses. Members went to respective host universities, such as AAU, DTU and RUC to study the Danish PBL model. Their observations were disseminated through more workshops as the course modules were being developed. The PBL approach in Denmark varies between universities such that RUC's approach is very much a student driven menu, the AAU model is the in-between and DTU is the other extreme, i.e. more traditional than PBL. Despite all of them being members of DUCED-I&UA, the differences are tolerated. Kjersdam and Enemark [9] concluded that different skills were acquired between the PBL (at AAU) and the traditional (at DTU) approaches. Graduates from AAU were comparatively stronger in management, communication, project work, problem-solving, cooperation and general technical knowledge but weaker in specialist and fundamental technical knowledge. Each model has its own merit and can be seen by the experiences captured in developing the course described in Section 3 below.

COURSE DEVELOPMENT AND IMPLEMENTATION IN ENVIRONMENTAL GEOTECHNIQUES

Course developers for the Environmental Geotechniques Group consist of two members from UM, two from UPM, and one from UTM. The group members have a background in Geotechnical, Geoenvironmental and Groundwater Engineering, and Engineering Geology. The topics covered in this course range from the mineralogical and geological aspects right up to the fate of contaminants and methods employed for containment and remediation in the ground. As the deadline approaches, the contents of the syllabus were often altered from its initial form to take into account overlaps and shortcomings. Within the time constraint of a 15-week semester, it was decided that the course would be regarded as a primer and thus would cover breadth rather than depth of the agreed topics. On this basis, the final content of the course module is as shown in Appendix B. For guidance to the instructors, an outline of each main topic is provided. A typical outline as found at the beginning of each topic in the module is shown in Figure 1[10].

In the March Semester of 2003, the course was conducted at UM for the first time. The March Semester occurs over the long vacation break between the normal semesters found in an academic year. Unlike the normal semesters, the course duration is 8 instead of 15 weeks. It was conducted wholly by the principal author who hails from UPM. The co-teaching of the course allowed for further networking and the sharing of resources amongst consortium members. Due to the short duration and taking into account the intense workload subjected upon the students (they normally carry two other 3 credit courses), it was decided that a qualitative rather than quantitative approach should be emphasized. In addition, at UM the course is opened to all engineering students and is pegged at an advanced standing undergraduate elective. However, graduate students can gain credit from it for graduation. The total enrolment was 18 undergraduate students, 14 having a background in Civil Engineering, 2 in Engineering Science, and 1 each from Manufacturing and Computer Engineering.

<table>
<tr><td colspan="2">Chapter 3: Groundwater Flow and Contaminant Transport (12 hours)</td></tr>
<tr><td>Objective:
The student will be able to:
• identify the principles involved in governing ground water flow and solute transport, and
• examine the theoretical and computer models available for prediction and analysis, including an introduction to modeling.</td><td rowspan="3">Lecture Topics:
3.1 Introduction
3.2 Groundwater motion
3.3 Groundwater flow modeling
3.4 Groundwater quality</td></tr>
<tr><td>Learning assessment:
Term paper, assignments, mini-project and a final examination on topics covered in this chapter.</td></tr>
<tr><td>Notes: Chapter 3: pp. 47-111
Slides: No. 3.1-3.40</td></tr>
<tr><td colspan="2">References:
Bear, J. ‘Hydraulics of Groundwater’, McGraw Hill. 1979
Todd, D. K. ‘Groundwater Hydrology’, John Wiley and Sons. 1980
Freeze, R. A. and Cherry, J. A. ‘Groundwater’, Prentice Hall. 1979
Walton, W. C. ‘Practical Aspects of Groundwater Modeling’, National Water Well Association, Worthington, Ohio. 1984</td></tr>
</table>

Figure 1: A typical topic outline of a chapter in the Environmental Geotechniques course module [10]

In the conduct of the course, much use is made of the course module that has been developed. The slides were used during the instruction class. Due to the syllabus requirements at UM, the topics covered during the course varied from the content of Appendix B by about 30%. At the end of each topic, quantitative exercises utilizing as much as is possible real data are included to strengthen student’s comprehension. The two local and one international case studies developed, one of which include socio-economic aspects, were presented during and towards the end of the course. Here, questions for discussion are posed and participation from the students is required. Accordingly, their contribution results in marks apportioned individually. Other forms of assessment include the typical final examinations (which at UM the norm is 60% of the total marks) and a term-paper due on the last day of the course. The term paper required the students to choose a topic title related to the course. The student is required to explore in depth a topic of special concern. In addition, a detailed account of one or more actual case studies dealing with a particular problem is to be included in the term paper. A tentative topic title and one paragraph abstract are required for approval one week before the final submission. On the day of submission, the students are required to do a short presentation of their work and copies of their term papers are provided to the rest of the class for review. Additionally, in the course of the presentation, the students are impressed upon that the solutions to environmentally related problems require a multi-disciplinary approach. The most economical and/or the most advanced technology may not necessarily be the ‘best’ solution when considering the different aspects of the problem. 20% of the total marks are attributed to the term paper.

The conduct of the course over at UM provided the opportunity for the course and the teaching methods employed to be assessed for the first time. Only 16 students responded in the questionnaire distributed for student’s feedback on the last day of the course. Appendix C shows the format of the questionnaire. For the purpose of this paper, only sections II and III, which have direct relevance, will be discussed in detail. The students were asked to rate on some aspects of the course and teaching methods in the respective sections. The scale employed range from 1 (‘disagree completely’) to 5 (‘agree completely’).

Table 1 shows the average values of all respondents to the statements posed in section II and III. One student responded in a manner that rendered the analysis of his questionnaire futile. The student consistently responded in the negative to the statements posed in section II and III i.e. either scale 1 or 2. On reviewing the personal details of the student in section I, he is found to repeat the course, having taken a similar course and failed previously in the normal semesters. The conduct of the course appears not to stimulate his interest nor make him want to pursue it further. Open-ended questions in Section V soliciting comments remained unanswered. The responses from this student, although included towards the average values of the scale in Table 1, were considered an outlier. Perhaps, for the student, this being his final semester only wants to graduate.

Table 1 indicates that in terms of the teaching methods employed, the course scores quite high. The students appear to benefit from fewer straight lectures and more two-way activity; like the discussion classes, and the assignments in which the students had to find out things for themselves, and/or having strong links throughout with the life of the community and its engineering problems. However, similar rating cannot be found with respect to the assessment of the course, although overall, the respondents agreed that the course is good. They found that the course is not that easy to follow (statement 6 scoring an average scale of 3.2) and that reference material to be inadequate (statement 7 scoring an average scale of 3.3). This could be due to the breadth and multi-disciplinary approach of the topics covered in the course. The students were sometimes required to find unfamiliar reference material as compared to their other engineering courses.

Table 1: Students' rating of the Environmental Geotechniques course and teaching methods at two participating universities of the MUCED-I&UA Environmental Engineering Programme

STATEMENT No.	AVERAGE VALUES OF SCALE[a]	
	UM	UPM
II. Course Assessment		
5	3.5	4.0
6	3.2	4.0
7	3.3	3.3
8	3.9	4.3
III. Teaching Assessment		
9	3.7	4.3
10	4.4	4.3
11	4.2	4.3
12	4.2	4.3
13	3.7	3.7
14	4.3	4.3
15	4.3	4.7
16	4.5	4.7

[a] Scale:

1 (disagree completely), 2 (disagree), 3 (disagree slightly), 4 (agree), 5 (agree completely)

In the November Semester of 2003, the course was offered by the principal author at UPM. This provided the opportunity to evaluate and assess the course at another participating university of the MUCED-I&UA Environmental Engineering programme. Unlike at UM, the course is opened to graduate students at the Faculty of Engineering only and conducted over a regular 15 week semester. Only three graduate students, all majoring in Geotechnical Engineering, elected to do the course. Two of the students are enrolled as part-time and the other is a full-time student. As described above, the traditional instructional approach is adopted and much of the conduct in running the course at UM is repeated at UPM. Classes were conducted in the evenings to accommodate their day-time jobs. In addition to the term paper, exercises and final examination, a problem-based mini-project is included as the principal mode of assessment. The mini-project required the students to work as a group and a project report and presentation is required at the end. Minutes of meetings held by the group, to be handed the day after, are used as indicators of the progress of their work and to assure individual accountability on aspects of effective teamwork. Which team member presents which part of the report is arbitrarily designated a short time before the reports are presented and a question and answer session executed on the individual presenter. The principal author serves as facilitator and resource person in all stages of the process to completion of the report. The individually assigned term paper required the student to explore in depth a topic of his or her own choosing. This involved independent literature and web search and promotes the sense of individual responsibility for lifelong learning. In addition, the term paper helped them to develop the skill to find and organize information in the absence of textbooks and course notes. The final exam covered all topics as outlined in the course syllabus. The proportion of marks as specified by UPM was distributed as follows: 20% for the exercises, 20% for the mini-project, 20% for the term paper and 40% for the final exam. The same format of the questionnaire as in Appendix C was distributed for student's feedback on the last day of the course. As the number of respondents at UPM is very small, it was also possible to conduct oral interviews based on their completed questionnaires. The average values of all three respondents to the statements posed in section II and III are shown in the respective column of Table 1. In terms of the teaching methods employed and the course content, the column indicates rather high scores. In the main, the scores are found to be higher than those indicated by respondents at UM. These can be attributed to the belief that the graduate students, especially working ones, having greater motivation to learn and the perception that they need to know the material being taught effectively. Statements 7 and 13 however required closer scrutiny. One respondent found that relevant reference material to be inadequate (statement 7 scoring a scale of 1; the others responded a score of 4 and 5 respectively). This respondent, a part-time student working in a structural engineering consultant firm, was found to be unable to satisfy the time demands required to balance her work duties and that of the courses she was enrolled in. The term paper and mini-project required her to be available for meetings and to utilise on-campus facilities. The breadth and multi-disciplinary approach of the topics covered in the course required the students to find unfamiliar reference material, especially in completing the term paper and mini-project, as compared to their other engineering courses. Respondents of statement 13 indicated a score of 3, 5 and 3 respectively. One respondent working in a routine geotechnical consulting firm indicated that the topics covered in the course is sufficient and that it was not necessary for him to pursue further in the area of environmental geotechniques. The one full-time student appears to benefit most from the course having indicated none of the associated problems of the part-time students. This respondent works in a government agency and is required to have a broad multi-disciplinary skill in his work.

At the present time, the approach to teaching is conceived as more of project-oriented instruction rather than truly problem based i.e. POPBL. The analysis of the above questionnaire can be regarded as one type of indicator for continuous course improvement. The course is at various stages of operations or academic approval at UPM and UTM. With full implementation, more data of students' response and other outcome indicators will be made available for analysis and for further improvement to be made on the course. The course outcome assessment results can be further used to map the programme level outcome assessments and performance targets evaluated. A programme outcome assessment matrix can indicate which courses might be modified, and the course assessment matrix for each of the courses in the programme can suggest areas that need strengthening.

CONCLUDING REMARKS

The MUCED-I&UA Environmental Engineering programme as currently envisaged is somewhat similar as that found at DTU. The courses are not organized under themes as in AAU and RUC. There is flexibility in the programme through transfer credit mechanism between participating universities. The developed and/or enhanced courses are organized as a separate entity although continuity, multi and inter-disciplinary approaches to problem solving are considered. These courses are assessed separately. The PBL approach is however expected from the learning assessments employed. As seen in the implementation of one such course, the POPBL approach is expected from the individual mini-projects and term papers assigned. Students are expected to draw the knowledge from the attended course and/or seek additional knowledge separately to solve the problem. Assessments made by the students indicate the good response on the POPBL approach. More data is required to make further improvements on the scope of the course content and for performance targets to be evaluated.

ACKNOWLEDGEMENT

The authors acknowledged DANCED, DUCED-I&UA and MUCED-I&UA for the assistance and financial support in capacity building and sustainable development in environment through research and higher education.

REFERENCES

1. Megat Johari Megat Mohd Noor, Abang Abdullah Abang Ali, Mohd Rasid Osman, Mohd Sapuan Salit, Norman Mariun, Mohd Saleh Jaafar, Abdul Halim Ghazali, Husaini Omar & Rosnah Mohd Yusuff (2001) A New Engineering Education Model For Malaysia. International Journal of Engineering Education 18(1): 8-16.

2. Yong, E. F., Azlan, A. A. and Tan, K. K., (1986) Environmentally Oriented Engineering Education and Environmentally Literate Engineers. Proceedings of the National Seminar on Engineering Education. Kuala Lumpur, Malaysia. Kuala Lumpur: Universiti Malaya Press.

3. Felder, R. M. and Brent, R. (2003) Designing and Teaching Courses to Satisfy the ABET Engineering Criteria. Journal of Engineering Education. Jan. 2003: 7-25.

4. Besterfield-Sacre, M. E., Shumay, L. J., Wolfe, H., Atman, C. J., McGourty, J., Miller, R. L., Olds, B. M. and Rogers, B. M. (2000) Defining the Outcomes: A Framework for EC 2000. IEEE Transactions on Engineering Education. 43(2): 100-110.

5. Felder, R. M., Woods, D. R., Stice, J. E. and Rugacia, A. (2000) The Future of Engineering Education. 2. Teaching Methods that Work. Chem. Engr. Education. 34(1): 26-39.

6. Edens, K. M. (2000) Preparing Problem Solvers for the 21st Century through Problem-based Learning. College Teaching. 48(2): 55-60.

7. Johnson, D. W., Johnson, R. T. and Stanne, M. B. (2000) Cooperative Learning Methods: A Meta analysis. <http://www.clrc.com/pages/cl-methods.html>, last accessed August 14, 2004.

8. Megat Johari Megat Mohd Noor, Abdul Halim Ghazali, Thamer Ahmed Mohamed, Badronnisa Yusof and Aziz F. Eluobaidy. (2002) Master of Science (M.S.) Curriculum in Water Engineering at Universiti Putra Malaysia. Proc. of 2nd World Engineering Congress. Sarawak, Malaysia. Serdang: Universiti Putra Malaysia Press.

9. Kjersdam, F. and Enemark, S. (1994) The Aalborg Experiment – Project Innovation in University Education. Aalborg: Aalborg University Press.

10. Azlan, A. A.; Aishah, A. B.; Roslan, H.; Norhan, A. R. and Zainuddin, M. Y. (2003) Environmental Geotechniques – A Course Module for Instructors. Kuala Lumpur: Malaysian Universities Consortium for Environment and Development - Industry and Urban Areas.

APPENDIX A: LIST OF ACRONYMS

The following are the main acronyms used in the paper:

AAU	Aalborg University
DANCED	Danish Cooperation for Environment and Development
DTU	Technical University of Denmark
DUCED-I&UA	Danish University Consortium for Environment and Development - Industry and Urban Areas
IWK	Indah Water Konsortium
MUCED-I&UA	Malaysian University Consortium for Environment and Development – Industry and Urban Areas
NGO	Non Governmental Organisations
PBL	Problem Based Learning
POPBL	Project-Oriented Problem Based Learning
RUC	Roskilde University
UM	Universiti Malaya
UPM	Universiti Putra Malaysia
UTM	Universiti Teknologi Malaysia

UKM	Universiti Kebangsaan Malaysia
WWF	World Wildlife Fund

APPENDIX B: CONTENTS OF THE ENVIRONMENTAL GEOTECHNIQUES COURSE MODULE

Chapter 1 Geoenvironmental Problems and Regulations
Lecture: 2 hours
Lecture Topics
1.1 Geoenvironmental and contaminated land
1.2 Soil contamination
1.3 The problem and its investigation
1.4 Geoenvironmental and contamination problems in Malaysia
1.5 Risk assessment and management
1.6 Remediation standards and regulation
Slides

Chapter 2 Environmental Geology
Lecture: 6 hours
Lecture Topics
2.1 Brief review of geological fundamentals
2.2 Rock and soil classification in engineering geology and geotechnics
2.3 Mapping, site investigation and logging
2.4 Environmental geohazards
2.5 Environmental geochemistry
References
Slides

Chapter 3 Groundwater Flow and Contaminant Transport
Lecture: 12 hours
Lecture Topics
3.1 Introduction
3.2 Groundwater motion
3.3 Groundwater flow modeling
3.4 Groundwater quality
Slides

Chapter 4 Waste Containment Systems and Development of Landfill Sites
Lecture: 11 hours
Lecture Topics
4.1 Characterization of urban wastes and its engineering properties
4.2 Review on engineering properties of soil
4.3 Soil-waste interactions
4.4 Waste containment systems (sanitary landfills)
4.5 Engineering problems associated with landfill
Slides

Chapter 5 Remediation of Contaminated Land
Lecture: 8 Hours
Lecture Topics
5.1 Introduction
5.2 Site characterization
5.3 Geostatistics
5.4 Contaminants release mechanisms
5.5 Identification of hazardous wastes
5.6 Exposure assessment
5.7 Estimation of clean-up levels
5.8 Treatment approaches
5.9 Pump and treat

5.10 Soil flushing
5.11 Volatilization and air-pressurization
5.12 Vitrification
5.13 Reactive wells
5.14 Solidification and stabilization
5.15 Chemical treatment
5.16 Monitored natural attenuation
5.17 Phytoremediation
5.18 Bioreclamation
Slides

Chapter 6 Case Studies
Lecture: 6 Hours
Lecture Topics
Case Study I – Contaminant Transport Modeling in Subsurface Systems
Case Study II – Planning for NAPL's Contaminated Soil-Groundwater Remediation
Slides

APPENDIX C: STUDENT QUESTIONNAIRE – ASSESSMENT OF COURSE AND TEACHING

SOAL SELIDIK PELAJAR: PENILAIAN KURSUS DAN PENGAJARAN
(STUDENT QUESTIONNAIRE – ASSESSMENT OF COURSE AND TEACHING)

Sila hitamkan pada kotak yang berkenaan. Pen (selain daripada merah) boleh digunakan untuk menanda. Gunakan cecair pemadam untuk memadam.

Sesi: Kod Kursus: Semester:

I. Butir Peribadi
(Personal details)

1. Dalam program pengajian anda, kursus ini merupakan:
(In your study programme, this course is)
   a. Kursus Teras Wajib Fakulti
   (Compulsory Faculty Core Course)
   b. Kursus Teras Pilihan Fakulti
   (Elective Faculty Core Course)
   c. Kursus Teras Pilihan Jabatan
   (Department Elective Core Course)
   d. Kursus Elektif Fakulti
   (Faculty Elective Course)
   e. Kursus Elektif Luar
   (Outside Elective Course)
2. Secara purata, berapa jam seminggu anda gunakan untuk mengulangkaji kursus ini
(On average how many hours a week do you revise this course?)
   a. Kurang dari 1 jam
   (Less than 1 hour)
   b. 1 hingga 2 jam
   (1-2 hours)
   c. 2 hingga 3 jam
   (2-3 hours)
   d. 3 hingga 4 jam
   (3-4 hours)
   e. lebih dari 4 jam
   (More than 4 hours)
3. Adakah kursus ini menimbulkan minat anda untuk lebih mendalami bidang ini? *(Does the course interest you and make you want to pursue it further?)*
Ya *(Yes)* Tidak *(No)*

4. Adakah anda mengulang kursus ini?
(Are you repeating the course)
Ya *(Yes)* Tidak *(no)*

Untuk bahagian II, III dan IV sila gunakan skala berikut:
(For sections II, III and IV use the following scale:)

Sangat tidak setuju *(Disagree completely)*	(1)
Tidak setuju *(Disagree)*	(2)
Kurang setuju *(Disagree slightly)*	(3)
Setuju *(Agree)*	(4)
Sangat setuju *(Agree completely)*	(5)

II. Penilaian Kursus Ini
(Assessment of course)
Beri pendapat anda tentang kenyataan berikut:
(Comment on the following statements:)
5. Skop kandungan kursus adalah sesuai. …
(Scope of course content suitable.)
6. Kursus ini mudah diikuti. …
(Course is easy to follow.)
7. Bahan rujukan adalah mencukupi. …
(Reference material is adequate.)
8. Pada keseluruhannya kursus ini adalah baik. …
(Course, on a whole is good.)

III. Penilaian Pengajaran
(Assessment of teaching)

Beri pendapat anda tentang kenyataan berikut:
(Comment on the following statements:)
9. Perancangan dan penyediaan kursus ini adalah baik. …
(Course planning and preparation is good.)
10. Pensyarah berpengetahuan tentang subjek. …
(Lecturer is knowledgeable in the topic.)
11. Pensyarah menyampaikan subjek dengan jelas. …
(Lecturer presents the subject matter clearly.)
12. Pensyarah menggunakan contoh-contoh yang relevan. …
(Lecturer uses relevant examples.)
13. Pensyarah merangsangkan minat anda dalam subjek berkenaan. …
(Lecturer stimulates your interest in the subject.)
14. Pensyarah berinteraksi dengan pelajar. …
(Lecturer interacts with the student.)
15. Pensyarah mengamalkan ketepatan waktu. …
(Lecturer keeps good time.)
16. Pada keseluruhannya pensyarah telah menjalankan kursus ini dengan baik. …
(On the whole lecturer has conducted the course well.)

IV. Penilaian Kemudahan Pembelajaran
(Assessment of facilities)

Beri pendapat anda tentang kenyataan berikut:
(Comment on the following statements:)
17. Kelengkapan dan peralatan pengaiaran kursus ini mencukupi. …
(Teaching aids and equipment for course is adequate.)
18. Kemudahan dan kelengkapan makmallbengkel/kerja lapangan bagi kursus ini mencukupi.
(Lab./seminar /field study facilities for the course is adequate.)

V. Komen-komen lain
(Other comments)

………

……