A Problem Based Sustainability Education Approach in Integrated Design Project Course

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Abstract: - Integrated Design Project is a compulsory course for final year students under Department of Civil and Structural Engineering (JKAS), Faculty of Engineering and Built Environment (FKAB), Universiti Kebangsaan Malaysia (UKM). This course is conducted simultaneously where phase I in semester VII and phase II in semester VIII. This IDP course takes the premise that problem-based learning is an effective way of delivering sustainability education. Through this course, students are exposed to the real situation of sustainable construction through design project task, site visit and a case study experience. The chosen project task involve most of the Civil and Structural engineering designs such as earthworks, drainage system, roads, water supply, sewerage system and buildings. Students’ need to come out with complete conceptual design and justify how they choosing appropriate design concept in which safety, sustainability and cost effectiveness are among the major considerations. The aims of this paper are to enlighten the aspects of sustainability in PBL and how it could be applied to the built environment undergraduate courses.

Key-Words: - Problem based learning, sustainability, integrated design project, civil engineering sustainability course

1 Introduction

Basically, the Integrated Design Project (IDP) course consists of 2 parts in which the first semester (semester VII) students are required to register for Integrated Design Project I course (KH4014) and in the second semester (semester VII) for Integrated Design Project II course (KH4264). This IDP course takes the premise that problem-based learning (PBL) is an effective way of delivering sustainability education [1].

This course aims to synergise all the basic engineering knowledge gained previously to solve real civil engineering problems in an integrated and comprehensive manner. In the first part, the students will be guided on the importance of choosing appropriate design concept in which safety, sustainability and cost effectiveness are among the major considerations. Their findings shall be in the form of written report as well as oral presentations.

Then, in the second part, each group is given a architecture layout and details of a project and a topographical plan of the proposed project site. They shall then prepare the conceptual design of various civil engineering components such the earthworks, retaining structures, drainage system, roads, water supply and sewerage. The deliverable of the conceptual design is a technical report complete with relevant sketches and shall also be orally presented by every group members. Grading shall be based on the conceptual report, oral presentation as well as peer assessment (respective group members).

2 Problem Based Learning

Problem-based learning (PBL) is a cooperative and hands-on student centred learning approach to teaching and learning based on group work/teamwork and problem investigation. With the desire to increase the numbers of students engaged in sustainability education, traditional PBL models have been adapted to be delivered in a less resource intensive way to larger numbers of students [1].
In this approach, learning arises with a problem to be solved rather than knowledge to be grasped during lecture. PBL was in the beginning introduced in order to help medical students learn the basic fundamental of biomedical sciences. The implementation of PBL is acknowledged due to the attractiveness of a high numerical efficiency in the PBL programme in the medical curriculum [2]. Since its origin in medical education, PBL evolution has been used in other settings such as engineering and architecture [3]. PBL includes among its goals: (1) developing scientific understanding through real-world cases, (2) developing reasoning strategies, and (3) developing self-directed learning strategies [4].

3 Sustainability
‘The environment’ and ‘sustainability’ are major issues of importance for government, and universities. All institute higher learning now include such considerations in their strategic planning and many have made a commitment to improving the ‘sustainability literacy’ of their students. The curriculum in sustainable development and technology is intended to cut across all engineering disciplines, within a multidisciplinary environment, incorporating the latest advances in cognitive science and computer-supported learning [4].

Sustainable development is obviously a complex concept, which concerns a wide range of social, scientific, economic and environmental interlinked issues [5]. World had move to highlight the environment and sustainability as major issues of importance nowadays. University should be also leaders in education to sustainable development to insure continuity with primary and secondary education [6].

4 Integrated Design Project
The KH4014 Integrated Design Project I and KH4264 Integrated Design Project II (also referred as Capstone Project) is the culmination of most if not all of the engineering courses undertaken by the students throughout the eight semesters they are in the JKAS engineering. The students are given real case studies, such as township, mixed housing developments and campus in the first semester and they have to continue with the same project in the second semester. In most cases the projects are at planning stages and students carry out their respective assignment concurrent with the design works carried out by the professional consultants.

The chosen project would normally involve most of the Civil and Structural engineering designs such as earthworks, drainage system, roads, water supply, sewerage system and buildings. Hence the execution of the design project would require students to apply almost all the knowledge gained in the course of their studies including the industry practical stint.

The students of this course are assigned into groups. Each group will consist of four (4) or five (5) students, membership of which is decided by the course coordinator. Each group is expected to elect their respective leader. Even though each team member will be required to champion certain design component all members are expected to understand and contribute in the design cycle. Minutes of regular technical meetings which shall form part and parcel of the conceptual and final design report will give a good guide as to the involvement of all members in solving all the design issues. Consequently the design project has been divided into two phases one for Semester I and the other for Semester II respectively.

4.1 KH4014 Integrated Design Project I (Phase 1)
Phase 1 constitutes discussion on design concept wherein all proposal and assumptions made are expected to be justified. Some guidance on the preparation of the design is given. One of the major emphasis during this phase is the concept of sustainability. The students are expected to compare pros and cons of projects that have been constructed and are currently in operation. Their critical comments on sustainability concept will cover the planning and the operation and maintenance aspect of the projects. The students shall also examine the basic consideration of functionality, safety and cost in their concept design. The components shall necessarily include earthworks, drainage, access roads, sewerage system, water supply and building structures.

At the end of the semester, students’ are expected to achieve five (5) Course Outcomes:

CO1: Able to describe/discuss/illustrate knowledge related to design solutions that takes appropriate consideration for 1) public health and safety, cultural, societal, and environmental considerations citing real situations, 2) concept of sustainability and
the need for sustainable development citing real situations, 3) professional engineering input towards societies, health, safety, legal and cultural issues citing real situations, and 4) project management and finance.

CO2: Able to investigate, assess and appraise real projects, with highlights on design solutions related to public health and safety, cultural, societal, and environmental aspects, 2) concept of sustainability and the need for sustainable development citing real situations, 3) professional engineering input towards societies, health, safety, legal and cultural issues citing real situations, and 4) project management and finance.

CO3: Able to develop design concepts for a given complex Civil engineering project to meet specified needs with appropriate consideration for 1) public health and safety, cultural, societal, and environmental considerations citing real situations, 2) concept of sustainability and the need for sustainable development citing real situations, 3) professional engineering input towards societies, health, safety, legal and cultural issues citing real situations, and 4) project management and finance.

CO4: Able to articulate project findings well in all sections from abstract, synopsis, introduction, executive summary, literature review, methodology, data collection, data analysis, discussions, conclusions, recommendations and suggestions (where applicable), and to defend the above in verbal presentation.

CO5: Able to assume responsibility and commitment towards given tasks effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.

These 5COs were mapped to the seven (7) Programme Outcomes (PO) as follows:

PO2: Problem Analysis (cognitive)
PO3: Design/Development of Solutions (cognitive)
PO6: The Engineer and Society (cognitive)
PO7: Environment and Sustainability (cognitive)
PO9: Communication (affective)
PO10: Individual and Team Work (affective)

PO12: Project Management and Finance (cognitive)

JKAS has adopted verbatim the 12POs as stipulated in Engineering Accreditation (EAC) Manual 2012 [7]. Each COs were mapped to respective related POs. Course Outcomes (CO) are statements of student actions or what the student is able to do as the course progresses. These statements are more course-specific and related to the course content. Meanwhile Programme Outcomes (PO) is the expected achievement of the level of knowledge, skills and abilities essential to each student by the time their graduation.

4.2 KH4264 Integrated Design Project II (Phase 2)

Phase 2 which involves detailed design follows the approval of the design concept. Besides manual calculations, students are encouraged to use professional software in their design. Deliverables at the end of this phase shall consists of detail design reports showing all assumptions made, typical engineering calculations and drawings. Students are also expected to prepare bill of quantities, in which detail description of the works involved shall be described and quantified. They are also required to insert appropriate standard works and materials specification and wherever necessary modify the same to suit the project. By the end of the second semester each team shall submit the deliverables mentioned. The students shall present their detailed design reports which will be assessed by two assessors, one of whom shall be a qualified professional engineer from among different staff or from private practitioners.

At the end of the semester, students’ are expected to achieve twelve (12) Course Outcomes:

CO1: Able to identify and describe project site and constraints including existing topography and terrain, sub-soil conditions, Civil Engineering infrastructure facilities (road and accessibility, drainage, water supply, and sewerage systems (if any), and elements important to sustainability development.

CO2: Able to critically assess and evaluate the project site before coming up with design concepts and solutions. To include any sign of distress such as erosion, soil condition, distance to the nearest existing facilities, accessibility, anticipated difficulties, etc.
CO3: Able to develop and propose design concepts and solutions for infrastructure elements design that incorporate sustainable development criteria (choice of site, construction techniques and materials such as the use of Industrialised Building System (IBS) etc.), economics, health and safety, ethics, etc.

CO4: Able to judge and manually carry out design of infrastructure elements (earthworks, road, drainage, water reticulation, sewerage) by applying relevant codes.

CO5: Able to design infrastructure elements and generate drawings using relevant computer software (Excel spread sheet, AutoCad and other design software).

CO6: Able to produce presentable design report containing executive summary, introduction, tasks distribution, concepts, design calculations, drawings for tender documentation, conclusions, etc.

CO7: Able to verbally present infra and sub-structures design project in presentation session.

CO8: Able to perform tasks individually and be an effective group member.

CO9: Able to prepare bill of quantities and cost estimation.

CO10: Able to behave professionally and practice moral ethics.

CO11: Able to execute life-long learning activities in project activities.

CO12: Able to develop or propose or incorporate or plan new structures from existing knowledge on the impact of professional Civil and Structural Engineering solutions in societal and environmental contexts and the need for sustainable development in the design project.

These 12COs were mapped to the nine (9) Programme Outcomes (PO) as follows:

PO2: Problem Analysis (cognitive)

PO3: Design/Development of Solutions (cognitive)

PO5: Modern tools usage (psychomotor)

PO7: Environment and Sustainability (cognitive)

PO8: Ethics (affective and cognitive)

PO9: Communication (affective)

PO10: Individual and Team Work (affective)

PO11: Lifelong learning (affective)

PO12: Project Management and Finance (cognitive)

5 Course Delivery

This course is using different type course delivery methods to make its’ more interactive and interesting to students’. Choosing the write methods is important because it can improve students’ understanding. Overall the main concept of this course is a PBL and student centered learning (SCL). IDP is design for students to be effectively involves in each learning session. It is a student centered learning method where students learn by working on real time problems and activities with the lecturers, as facilitutors [2].

5.1 Essay writing

The first task in phase 1 is essay writing. Students are free to choose any topic as long as it’s related to sustainability. This assignment act as kick-start and must be submitted during the second week of the semester. By this way, lecturers are able to know level of students’ knowledge and understanding in sustainability. Thus, lecturers can plan suitable learning topics complete with example to enhance students’ in sustainability concept.

5.2 Sustainability development concept comparison

The second task in phase 1 is sustainability development concept comparison. A typical and closed example for students’ is the various developments taking place around the UKM Bangi campus. They must compare sustainable development in 3 different places which is 2 places inside UKM Bangi campus loop 1 and loop 2 and nearby city, Bandar Baru Bangi. From here, students’ starts to work in a group and this group will remain until the end of semester of phase 2. By the middle of the semester each team is required to submit and present their findings in the form of reports and oral presentation on the concept of sustainability based on their observations of the existing buildings and infrastructure. Students’ must conclude and justify their findings which place has
the most sustainable development. This would account for 40% of the overall marks for KH4014. Purpose of this task is to develop and expand students’ understanding on concept of sustainability development in the form various aspect such as safety, finance, society, culture, environment and etc.

5.3 The project
After students’ complete both earlier task, the real IDP project will begin. The project starts with site visit to the project site in week 5 of the semester. This PBL task involves a 405 hectares, ‘Hijauan Heights’ project in Pedas, Negeri Sembilan, Malaysia currently being jointly developed by two private company. It is planned to be developed based on ‘environmentally friendly’ concepts and comes with fruit orchards. The project site is located on an existing oil palm plantation estate, known as Ladang Air Hitam. It is bordering the Angsi forest reserve that has a beautiful natural water fall and Pedas dam. The development is currently underway. The land has been sub-divided into individual lots, each of 1 acre in size.

The developer has constructed a road network system to and within the project site, two (2) dams and lakes, some basic drainage, water reticulation system, and recreational facilities (for paragliding, fishing, jungle trekking) etc. Students are brought to see real development involving construction of various infrastructures and structures involving cut and fill and earthworks, drainage, water supply, drainage, slope stability/earth retaining structures, lake and dams, water retaining structures, etc.

Firstly, students’ need to conduct a strengths (S), weaknesses (W), opportunities for improvement (O) and threats (T) analysis of the project. They are required to identify current or potential future problems that have or may arise from the point of view of the impact of the project onto the environment and sustainability, cultural, society, public health and safety, and economics.

They started this project by identifying existing available relevant information and data that is required for successful execution of this PBL. Some of the information and data was provided by the developer, such as the topo map. However, some other important data need to be requested or obtained through students’ own initiatives, i.e. students’ need to identify the data required and where and how to obtain them.

Students also need to describe the already developed infrastructures and structures, with sketches of plan and cross sections of the various already constructed infrastructure and structure facilities, indicating clearly existing facilities from which the developed ones have been joined to.

The PBL involves several main components, namely:
1. Overall development concept for both infrastructures and structures including project development cost.
2. Catchment area, water resources and quality and water retention/detention/lake.
3. Dam and water gate structures.
4. Drainage system.
5. Water supply.
6. Sewerage system.
7. Road system.
8. Earthworks/platform and slope stability system.

Each group will be assigned to plan and design only one part of the main component. Each group also must find a mentor to help them in executing this project. The mentor must be a professional from industry. Course coordinator only provides list of contacts professional engineering and students must approach and choose their mentor by themselves. By this, students’ can get more information and knowledge from their mentor real experience while working at real site project.

As mention in earlier; during phase 1, students will propose and presented a conceptual design and after evaluation and comments by panel, students will implement design to the site project in phase 2.

5.4 Case study
Case study is important to expose students to real sustainable construction project in order to help students’ witness what, and how real sustainable development conducted. What to be expected and unexpected factors need to be consider in their project. Their case study is Tasik Chini, the second largest fresh water lake in Malaysia and is made up of a series of 12 lakes.

This case study task consists of two (2) activities. The first activity is a seminar by professional who involves in that construction was arranged in week 6 of the semester. During seminar, students’ able to know and ask the panel how they develop a sustainable construction. Later on, a site visit to the Tasik Chini was arranged in week 9 of the semester. Duration of site visit is three days two nights. It’s
more a like a camp for students. Camp for them to experience living in natural nature environment to make them more appreciate sustainable development. It is also to help students to take off and rest a while from busy and polluted city environment.

Students’ can observe there are many projects for rehabilitation of the Tasik Chini and surrounding that has been environmentally disturbed by the construction of a barrage at the estuary of Sg. Chini before it flows into Sg. Pahang, palm oil plantation, mining, logging and other activities that have caused many problems to the area. Amongst the problems are: sedimentation of Tasik Chini, contamination on the water of Tasik Chini due to pesticides and fertilizers from the palm oil plantations, slope stability problems due to the high water level and waves created by tourist carrying boats, growth of alien flora such as Curbumba furcata in the Tasik Chini, high level of E-coli and Salmonella in Tasik Chini due to the unproperly treated sewage affluent from the nearby PLKN camp, etc.

Students’ are also brought to witness the implementation sustainable design concepts in the Architectural and Civil Engineering aspects, such as the development of a Fresh Water Lab Complex (FWLC) for the Tasik Chini Research Center (PPTC) which involved a minimum cut and fill site or minimum disturbance to the original ground, building on stilts to avoid earthworks, the adoption of structural steel framed structures and composite slab (profiled steel decking and concrete) system, Onsite Detention Pond (OSD) and a wetland to treat the affluent from the sewerage system, etc.

6 Project Assessments
Assessment is a process where we can evaluate students’ performance. And it’s more important to make sure the process is fair and accurate. Evaluation are done using rubric. We are using explicit and specific rubrics for each type of assessments. IDP I and IDP II are access explicitly therefore students’ must succeeds in IDP I first in order to continue IDP II.

6.1 Design report
Reports on the design concept shall be submitted before the end of the semester followed by presentation session. This will account for 60% of the overall marks of the phase 1. Assignments/task given contributes only 5% of the overall marks. Meanwhile for the phase 2, the detailed engineering reports and bill of quantities accounts for 50% and 15% of the overall marks respectively. Besides group design report, students’ must prepare a individual portfolio. This portfolio purpose is to differentiate each student works.

6.2 Project presentation
Overall IDP course contains three (3) times oral presentation which is two (2) in phase 1 and one (1) in phase 2. Phase 1 presentation contributes 10% meanwhile phase 2 presentation contributes 25% of the overall marks.

6.3 Peer assessments
Besides direct assessments by panel, IDP also counts in peer assessments to evaluate students’ ethics, teamwork and leadership. This peer assessment contributes 5% and 10% in phase 1 and phase 2 respectively. We see peer is the most suitable to evaluate the three (3) items because they more aware of their members group real personality.

7 Conclusion
Problem-based learning is the main concept applies in delivering Integrated Design Project course in Department of Civil and Structural, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia. This course consists of 2 phase and it’s involve real case of sustainable development. Using real example promotes better students’ understanding on the concept of sustainability. And from year to year, it’s has help to enhance students’ in understanding what is sustainability concept.

Acknowledgements
This research is funded by the Centre for Engineering Education Research, University Kebangsaan Malaysia under Prof Dr Azami Zaharim (PTS-2013-014). The authors would like to thank the University Kebangsaan Malaysia (UKM) under Action Research Grant for funding this research.

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