Creating a self directed learning environment: Module design and implementation.

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Abstract— This paper deals with application of innovative curriculum and assessment to enhance deeper learning in students. A final year course in Power engineering is redesigned to address the changing nature of power engineer's job. It also addresses issues in teaching and learning. Active learning strategies are designed to promote deeper learning. The results on a sample class are presented.

Index Terms ¾ Contract grading, flexible assessment, self directed learning.

INTRODUCTION

Professional education such as engineering is a life long endeavor. Learning continues long after the learner has left the formal tertiary education institute. Hence a learner should develop skills and understand the process of self learning. Student centered learning plays an important role in tertiary education as it empowers the student to direct his/her learning. It has been seen that such self directed learning is more effective and deeper than that in the traditional model of teaching and learning.

In traditional form of learning in a lecture tutorial format tends to produce passive learning. New learning paradigms have been introduced such as Problem Based learning (PBL), Small group learning/teaching. However such techniques on there own may not lead to effective learning. In order to induce deeper learning among students an integrated approach to curriculum design is necessary. Curriculum includes the objectives, content, learning methodology and assessment.

CASE STUDY

The power engineering education is an integral part of the Electrical Engineering degree. It has existed since the birth of electrical engineering when electrical engineering itself was a taught along with mechanical engineering. Power engineering is taught typically in three modules: Power systems, electrical machines and Power generation and utilization. In addition to these, some special courses like protection and high voltage are offered as electives.

Recently, there are sweeping changes occuring in power engineering education. The nature of power engineering is also changing. The generation technologies are becoming advanced. Moreover, ecological aspects are gaining importance. This domain is more and more becoming specialised area for Chemical and Mechanical engineering. In addition the changing nature of the power industry itself is changing the role of the power engineer. Deregulation and privatization of the power industry the world over is changing the role of the electrical power engineer from technical to a managerial. The skills required of an electrical power engineer are increasing. How can the power engineering courses at undergraduate level keep up with this changing nature?

Another issue which concerns all university educators is how to empower students with skills of life long learning? In addition we wanted to investigate how curriculum change and assessment influence learning in students. Deep learning as opposed to surface learning is desired in students. However much to our chargin we find that a large part of the class end up having surface learning. Regurgitation of knowledge, learning for the exam and lack of motivation are common complaints about students. However most of this complaints are symptoms of poorly designed curriculum, excessive assessment and increased stress among students.

In this paper we report a study that involved redesign of power engineering course curriculum and assessment method. This was carried out at University of Queenland, 1997, semester II. We will report the evaluation of the changes carried out based on student feedback. This report shows a method of improving learning in students, impart life long learning skills and in addition show how to optimaly utilize resources available in the department by using the internet.

LEARNER PROFILE

To design effective learning and assessment strategies it is important to understand the learners profile. Often a faulty estimate of the profile leads to ineffective learning. The learner profile can be broadly divided into three types: absolute novice, fairly proficient and expert. Attitudes towards learning depend on learners profile. The learner of the first kind acquires knowledge through the process of transmission. The learner has to be made aware of methods of learning which will lead to deeper learning. A fairly proficient learner has developed the methods of achieving deeper learning. However some skills may not be fully developed. On the other hand an expert is proficient in the art of learning and self-assessment.

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The power engineering course we deal with is a final year course. At this level we expect a fairly proficient learner. But even at this level we may have a fairly proficient surface learner. This can be attributed to the years of conditioning by incorrect learning methods.

REDESIGN OF POWER ENGINEERING COURSE

A final year elective Electrical Energy conversion and utilization was considered for the project. The students have already done a core power and machines course. They have also done the core courses in power engineering stream such power system analysis and electrical machines. Hence the students have been exposed to the basics of power systems. The final year elective dealt with the following topics in more detail than the first course in power. Generation technologies, transmission and stability and utilization issues such a demand side management. This elective is offered in the final semester of the four year Bachelor of Engineering course.

In past the course delivery was fairly traditional. Lectures were a standard form of delivery of knowledge. Often engineers were invited to give lectures in special areas. Site visits were arranged and few lab experiment were designed. The assessment consisted of a case study report and a final exam. The students approached the course like any other undergraduate course. The fact that they were almost engineers and about to finish their degree had not made any appreciable change in their learning approach. They were fairly proficient in learning for the examination. Hence we couldn't really say that they had inculcated the skills for life long learning. Secondly though the practicing engineers had been invited to lecture them, the students were not really exposed to real life scenarios of the profession. The lectures were often one way delivery of information. Due to the form of delivery there was no scope for an interactive session. Added to this, the students were almost novices with regards to the special topics. This also inhibited effective interaction. Moreover since the assessment was traditional whatever good which was intended by inviting the practicing engineers was lost, as there was no motivation or credit given for inetraction with the professionals. At the end of the semester the course lecturer asked for exam questions from the invited speakers for their area of the syllabus. Not only did this create anxiety among students but it would also not enthuse the invited speakers. There was the fear of failure in students and this lead to surface learning. In addition, the content of the course has more breadth than depth. Hence it is difficult to keep students away from surface learning. In the view of the above short comings it was decided to redesign the course.

The redesign was to address two main objectives. The first one was to influence student's learning and the second was to address the requirements of the power engineer in the changing scenario of the power industry. The redesign would try to influence students

- towards deeper learning strategies
- develop life long learning skills
- to control and direct their own learning.

To address the changes occurring in the power industry the course would be designed to

- give students the knowledge about the needs of the power industry
- introduce students to the recent developments in the power industry in areas of generation, transmission, management and utilization
- put students into simulated real life scenarios of power engineering

To achieve this objectives the redesign was carried out on certain pedagogical framework.

MANAGEMENT OF LEARNING

One of the objective of the redesign of this course is to induce deep learning in students. Erickson [1], Andereson [2] and Gagne [3] have pointed out certain principles of managing learning. The important factors among these

- Learners should be active: significant learning occurs when learner is active in processing the knowledge and forming links with the existing body of knowledge.
- Learners should get feedback and opportunity for second try: feedback is essential to find out what the learner did right and wrong. Moreover an opportunity to learn from the past and to improve should be provided.
- The learning objectives should be known to the learner. If these are not clear learning progresses at a slower pace and the motivation is also poor. Clear learning objectives focus the energy of the learner to the task.
- Each individual is a unique organizer of knowledge. Hence it is important that the freedom and the time be allocated so that each learner can processes the knowledge according to their schema
- Successful learner engage in meta-cognitive knowledge and experience. Learners should develop self-awareness and knowledge about one's own regulation and cognitive process.
- The learner must be committed and motivated to learn. Student's motivation is affected by the classroom social and the task structure.

The lecture tutorial format of managing learning is not the most efficient way to produce active learners. In the lectures there is very little opportunity for active learning. As each learner has his/her own schema of processing knowledge, the lecture format inhibits active learning.

Moreover an instant feedback and opportunity to retry is not possible in this lecture-tutorial. Keeping this mind a different approach was taken for the proposed course. The class was designed in a group discussion format.

This was also in line with the course objeactive: put students through simulated real life scenarios. The group discussion took a form of a meeting and involved role playing. Such a format was possible as an elective course such has this would have at the most 20 students. In view of the role playing each student was required a name plate for the meeting. The lecturer also joined in as an equal but would keep the involvement to a minimum. The meeting would be chaired by one of the students.

Learning is focussed if learning objectives are clear. It is enhanced if appropriate resource material is provided. To this end the learning objectives of each class meeting were state clearly and published on the course website well before the course started. The reading material for each class was lisyed and was made available to the students at the physical sciences and engineering library of the university. The students were required to prepare a pre-dicussion summary before comming to the class. By defining the learning objectives and providing the resource material, the learning was focussed. The schedule is presented in the following table.

Week 1	Week 2	Week 3
Course Introduction	Generation: Deciding factors, global warming, energy demand. Reading 1,2,5 (from reading list)	Generation: Technology, economics Reading: 3, 4, 6 Guest Speaker: (Power Link)
Week 4	Week 5	Week 6
Generation: advance technologies and econmics Reading: 7,8,9	Generation: Photovoltaics Readings: 10, 11	Case study: Remote area power supply using PV Guest speaker: (AUSTA)
Week 7	Week 8	Week 9
Wind energy Reading: 12 Assessment 1	Transmission: Basics Requiremnets, Problems Reading: 13, 16	Transmission: Advance Technologies Reading: 14, 15 Assessment 2
Week 10	Week 11	Week 12
Market place:Deregulation, pricing Reading: urls Guest speaker: (Energex)	Utilisation: demand side management Reading: 19, 20	Power quality Reading: 21, 22
Week 13 Assessment 3		

Moreover the preparation of the pre-discussion report on the basis of the reading list allowed each individual learner to organize the knowledge and build concepts according to their individual learning schema's. In the ensuing class meetings students introduced issues and they were discussed. This allowed for active learning as well as instant feedback. Lecturer, as the facilitators, saw to it that the participants did not get stuck at one issue. The students were encouraged to address each other using the names on the respective name plates. Thus the class and social structure was made horizontal. The lecturer was also an equal participant in the sense that he also had to prepare his own pre- and post discussion summary reports. The tutorial session was used for peer assessment of the reports and a forum for discussion on course related issues from the course content assessment and management. This was necessary because of the method of assessment used.

FLEXIBLE ASSESSMENT AND CONTACT GRADING

Each individual learner has his/her own goals and motivation. Success in assessments depends on whether the learner has a good self-perception of academic confidence and outcome control. Moreover the learner should be aware of the cause and effect relationship between success and failure. In order to focus the learning to match the goals of each individual learner a flexible assessment was designed. The form of assessment could be selected by each student at the beginning of the semester. This is also called as contract grading. The standards and requirements of each assessment are made available to student at the start. These assessments were structured in terms of the degree of difficulty to match the Universities grading system. The degree of difficulty involves increasing use of cognitive skills and effort. Each assessment type however required all the learning skills as given by Bloom's taxonomy [4]. The different forms of assessment will be explained.

The assessment common to all the students requires each student to participate in the class discussions. In addition , each student is required to prepare a pre- and post-discussion summary. These summaries are peer assessed in the tutorial class. A feedback sheet, which can be downloaded from the course web site, is used by each peer assessor. The criteria and standards on this sheet are

Writing

Objective well defined 6 5 4 3 2 1 0 ill defined/vague objective

Clear and concise 6 5 4 3 2 1 0 difficult to read

Cover all aspects 6 5 4 3 2 1 0 covers only narrow topic of the paper

Correct English Language 3 2 1 0 needs improvement

Subject

Student has summarized 6 5 4 3 2 1 0 just repeats what the paper says ideas clearly

Original Ideas presented 6 5 4 3 2 1 0 mere statements of facts

can be used as reference 6 5 4 3 2 1 0 no reference value

The students is required to satisfy the following requirements to a) participation in discussions b) successfully completed peer assessed pre- and post - discussion summaries. Under such condition the student has satisfied the criteria to get a PASS
grade in the course.

In addition to satisfying the criteria for the PASS grade the student can opt for any of the three higher forms of assessment methods. They are listed here in increasing degree of difficulty

- Class test at the end of each assessment period. The test will cover the topics of the syllabus discussed in the class meetings. The student is required to show the depth of knowledge, analysis and evaluating skills in these topics

- Class test at the end of each assessment. The test will be one a topic of student's choice which has not been discussed in the class but is linked with the topic covered in the class. The student will research on such a topic in consultation with the lecturer. The student will submit the learning objectives for the topic to the lecturer. The lecturer will advise the student on the topic and the learning objective to ensure the standard of the assessment. The lecturer will prepare a test based on the learning objectives. In addition to the class tests the students submits a report on one of the topics.

- Problem-solving project. The student will select a problem in the area related to the course. The student will go about solving this problem. Assessment will be continuous and will involve a progress discussion with all the students opting for this form of assessment. The student is required to submit a project report and present the project at the end of the course.

Each student has the possibility of upgrading or down grading the type of assessment. However while doing so the student has to take at least two assessment of that criteria. This gives the students the flexibility to set their goals and control the outcomes of their assessment.

FORMULATION OF THE TEST

The tests for the two criteria of grades were based cognitive skills as proposed by Bloom [4]. The assessment was criterion-referenced and also should the level of maximum possible outcome in each of the criteria. Such a table is shown below

Skills	Questions	Answer
Knowledge	xxxx	
Concepts	xxx	
Analysis	x	
Evaluation	x	

Assessment for Grade 5

The assessment table for Grade 6 where each student is studied on a topic not discussed in the class but related to the course is similar to the above table. However the test is prepared such that higher outcome is expected in areas of conceptualisation, analysis, synthesis and evaluation. The knowledge skills are not heavily weighed. This is specifically done to avoid students from just regurgitating the knowledge form their researched literature. A conscious effort is made to ask students to relate the ideas from the topic of their choice to those discussed in the class meeting. To illustrate here is an example of grade 5 and 6 tests for the portion on Generation of electricity. The grade 5 questions were

Q1. What are the power generating sources available today? Draw a typical load curve and state which type of power plant is suitable for base load, intermediate load and the peak load conditions.

Q2. Give a pie chart describing the share of different resource used to generate electricity today. What, in your opinion, would be the structure of this pie chart say 20 yrs and 50 yrs from now? List the reasons for the change.

Q3. *The present generating capacity of Queensland is about 6500 M'W. Assuming a very high growth in demand in next ten years of about 3000 M'W, discuss the options available to power companies. What are the factors you will look for while selecting a particular power plant technology. Propose a plan to be presented to the ministry which will meet the demand at optimal cost. Consider also the environmental implications.*

Now any student attempting to satisfy the criteria for Grade 6 had to select a topic not discussed in class but closely related to the topic. The generation technologies and resources discussed in class were coal, natural gas and their generation technologies whereas photovoltaic and wind power in the renewable energy resources. All other technologies were touched but not discussed thoroughly. Students could choose from any of these technologies and define their learning objectives. Here is an example to illustrate the process of assessment for grade 6. Firstly the student does preliminary research and selects a topic. Student X had selected Fuel Cells as a technology for generation. This student came for consultation with a bunch of books on Fuel Cell technology. These were highly technical and required a fair amount of expertise in electrochemistry. The lecturer then explained to the student

the role of an electrical engineer, where the engineer is called upon to evaluate and select an appropriate technology. The student then came up with set of learning objectives from the resource material he had researched from the web site. They were a) To be able to know the working of the Fuel Cell b) to know the different type of fuel cell technologies available and to be able to evaluate the technologies. A third objective was included on advice of the lecturer. This was to be able to compare the fuel cell technology with the other means of generation. The questions set on the learning objectives were.

Q1. Explain the basic principle behind the working of the Fuel Cell

Q2. Briefly give the types of fuel cells and state their operating characteristics.

Q3. For oil rig located in tropical region a power source is required. Assume that the load is about 200 kW. List the possible ways of power generation. Evaluate the advantages and disadvantages of different sources. Though oil is available it cannot be used as fuel until it is processed, however oil wells also produce gas. Evaluate how .fuel cells could be used in this scenario. Give a proposal for an optimal solution of power generation.

The last question requires the student to fall back on the ideas discussed in the class meeting. It also requires the use of analysis, synthesis and evaluation. The other topics also included a similar form of test. The first two questions would be on knowledge, concepts and analysis while the last question would be on synthesis and evaluation in addition to the qualities listed above.

The students who wanted to attempt the grade 7 criteria were required to do a problem solving project. In the first stage the student had to decide on a problem related to the course. They could consult the lecturer but the problem had to be their own. This was specifically stated and explained. The motto was: are you interested in solving a problem which you feel requires a solution than do so. If you don't see a pressing problem you will not be provided with one. The students did some research and came back for consultation. They were advised on the problem they had selected. The lecturer ensured that they hadn't taken up a problem which they couldn't solve in the allotted time. The topics selected were

- Design of a stand alone power system for a south east Queensland island.
- Request for Tender for the supply of electricity for University of Queensland.
- Energy Utilisation in a Household and Demand side Management.
- Energy Audit in Existing commercial Building.
- A case study of the energy auditing of the Therapeutic Radiology Department, Singapore General Hospital.
- Energy audit and cost analysis for Bioscience library of University of Queensland.
- Solar energy implementation: cost benefit analysis.
- Drive and Battery requirements for a three wheeler electrical vehicle.
- Battery Requirement for the solar racing car SUNSHARK.

The projects were assessed during the assessment period by all the project participants. Each student had to explain the work progress and the goals for the next assessment. In doing so the progress was closely monitored. The students were advised if there was fall in the desired standard. Two students opted for other grading criteria after the first assessment. One student continued despite having been advised to defer. The student eventually managed to pick up pace and finish the project. However the quality of work being poor was awarded only a PASS. The rest of the students maintained steady progress and finished the project without overheads.

EVALUATION

In order to evaluate the effects of the method of delivery and the assessments three evaluation tools were employed. First one was the approaches to learning questionnaire by the Tertiary Education Institute (TEDI). The other two were the teaching and subject evaluation questionnaire also supplied by TEDI.

To the question whether the subject objectives were fulfilled as stated in the student Guide

strongly agree	50%
Agree	50%
Uncertain	0%

To the question whether the assessment criteria clearly spelt out

strongly agree	50%
Agree	35%
Uncertain	15%

Management of learning

Adequate information and resources were available to students.

strongly agree	50%
Agree	45%
Uncertain	5%

Topics were well structures

strongly agree	21%
Agree	74%
Uncertain	5%

Case studies and simulations are valuable part of this subject

strongly agree	52%

Agree	48%
Uncertain	0%

Opportunities to ask question and participate

strongly agree	85%
Agree	15%
Uncertain	

Learning attitudes

My critical abilities have increased during the subject

strongly agree	40%
Agree	50%
Uncertain	10%

I have learned to apply principles from this class in new situations

strongly agree	32%
Agree	64%
Uncertain	4%

I have learned to feel responsible for my own learning

Strongly agree	48%
Agree	48%
Uncertain	4%

I have learned to make connections between this subject and the others

strongly agree	28%
Agree	60%
Uncertain	12%

I prefer the student centered lerning structure of this subject to the standard lecture format

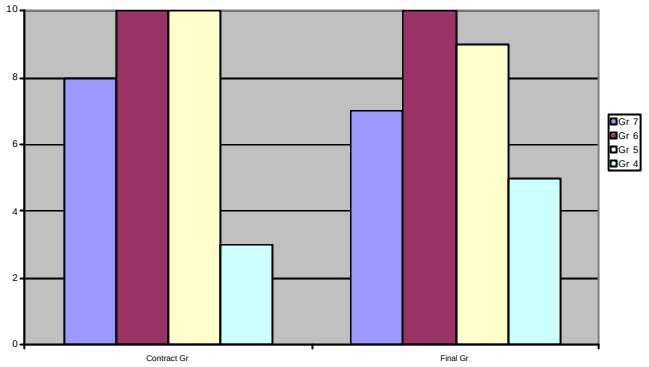
strongly agree	36%
Agree	56%
Disagree	8%

I like the assessment requirements

strongly agree	60%
Agree	36%
Uncertain	4%

REFLECTIONS

The findings of this case study show that learning progresses when learners are active. The structure of the delivery and the assessment has greatly enhanced the ability of the students to perform at their chosen level. By allowing different types of assessments each students could choose the level of difficulty s/he wanted to attempt. The course content as such has more breadth and hence in a conventional class the tendency for surface learning is greater. In order to mitigate this problem the student is actively involved in discussions and others assignments which promote comprehension and cross migration of ideas. Moreover by providing transparent assessments the fear failure can be minimized. The contract grading success is reflected in the following chart.



The histogram on the left is the profile of the contract grades where as the histogram on the right is the histogram of the final grades. Of the Grade 5's two slipped to Grade 4. While one student who opted for Grade 7, did not manage the required standard. The format of the course and the assessment has produced encouraging results. The format as such may not be applicable to all courses, however the basic principles are. Curriculum has to be structured to promote active learning. Feedback and possibility for second tries should be provided. The fact that each individual learner has a schema has to be respected. On the basis of these sound principles innovations in Engineering curriculum and assessment are possible.

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