

# ASSESSMENT TOWARDS IN-DEPTH AND STUDENT CENTERED LEARNING

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**Abstract**  $\frac{3}{4}$  Learning is a basic human trait. Very basic learning is fuelled by basic needs of survival. Learning at tertiary level of education should be more in-depth. Assessments have an effect on learning. The paper shows the relation between assessment and learning. How can assessments be used to promote in-depth learning. The paper seeks answers to this question. A case study result is presented.

**Index Terms**  $\frac{3}{4}$  Assessment, criterion-referenced assessments, in-depth learning, and learning taxonomies.

## INTRODUCTION

I will start this paper with the following two quotes:

“All human beings, by nature, desire to know” – Aristotles;  
“...Abandon judging, and the people will return to their natural affections” – Tao Te Ching, Lao Tzu.

The two quotations succinctly describe the problem at hand. Learning is a natural process and is driven by various motivating factors. Assessment on the other hand is to take account of what is being learned. If assessments are used unwisely they can become the goal of learning rather than the means to the goal.

The primordial urge to survive is probably the most common factor for learning. A. A. Root [1] has classified learning motives on heirarchical structure. Derived on the basis of Maslow’s theory, the motivating factors arise from the basic physical and organisational needs and grow towards social needs. At the top of this structure are aesthetic needs. According to Root, once the physical and social needs such as need for belonging and self-esteem are satisfied, the growth in learning moves to motivating factors that are internal. Prior to reaching this stage the physical and social needs have to be satisfied.

## ASSESSMENT

Assessment is to identify if the choosen learning goal is being reached or satisfied. Hence assessment should be designed to match the learning goals. However the mode of assessment is also influenced by external factors. In tertiary education and particularly professional courses the society and the professional bodies have a stake in setting the learning and proficiency goals.

Assessment deterring the level of proficiency reached by the learner are called summative assesments. Assessments, on the other hand, can also be used to enhance learning by

means of feedback. In such case the assessment is formative. The summative assessment is the level of success in reaching the desired goal. It is called an educational measurement [2]. It is defined as a quantitative assessment of an ability of an individual to carry out a given task. This task may be tested using an instrument such as a class test, a laboratory test etc. Broadly known as achievement tests, such tasks help the instructor to find the level of competency reached by the student. The degree of success attained by the student in the assigned task is defined as grading.

The traditional method of assessment in engineering education has been of summative nature. This coupled with other factors such as maturity of students, declining standards in maths and science at high schools and increasing workload have led to surface learning by the current group of students. The primary goals of the majority of students seem to be “learning for the exam”. However, that certainly is not the primary goal of the engineering education. In order to mitigate this problem of shallow learning, various factors have to be addressed. Some of these may not be within the domain of tertiary education. However, redesigning the curriculum to tailor the work load is within the domain of the Universities. Attempts such as “Wipe-the slate-clean” project carried out at the Carnegie Mellon University is a step in this direction [3]. However to address the root cause and to change the mind set of students a redesign of assessment and grading is also required. This paper addresses the problem of how to design assessment and manage learning to satisfy diverse learning goals to induce deeper learning. We will discuss assessment for electrical engineering education.

## ASSESSMENT AND ENGINEERING CURRICULA

Over the years professional bodies have tried to update these goals to keep pace with the changing nature of the profession. However, a set of goals keeps reappearing in these studies. They are:

- To broaden the scope of engineering education by including high-quality social science and humanities courses.
- To increase flexibility of curriculum to encourage a wider range of subject matter at both undergraduate and graduate level.
- To reorganise engineering careers in design, development, management, and all engineering functions as desirable educational objectives.

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- To reorganise continuing education as a distinct function.

These recommendations were made as early as 1968 by the American Society of Engineering Education (ASEE) and they are still very relevant to engineering education. The first two goals are regarding curriculum design but the third goal in particular is recognising the different roles of an engineer. In comment to these recommendations the IEEE says "... This flexibility (in curricula) is highly appropriate since the relative importance of various specialities continues to change rapidly, science advances and as social problems begin to influence technical components of curricula. Furthermore, students are individuals. Engineering education should capitalize on this individuality by permitting each to tailor a program suited to his (/her) own interests and talents"[4]. In order to satisfy diverse learning goals as stated in the recommendations, a redesign of the management of learning and assessment is necessary. Criterion-referenced assessment can be used in a novel way to this end. On the other hand norm-referenced assessment, where an individual's performance is measured against the class performance would be detrimental to diverse learning goals. Criterion-referenced assessment, where criteria satisfy the different educational objectives, such as engineering functions, should be able to enhance learning. By allowing the individual to take charge of their learning through assessment, deeper learning can be encouraged. Thus mitigating the "learning for exam" syndrome.

### CRITERION- OR NORM-REFERENCED ASSESSMENT

Traditionally two forms of grading have been used in tertiary education a) absolute marking and b) relative marking. Very early the gradings were in absolute marks or percentages. Later a relative marking on the basis of five letter A-B-C-D-F system was introduced [5]. The percentages of A's and B's would be decided by using the normal distribution curve. Both methods of grading are prevalent today. While a majority of institutions use the norm-referenced grading some of the institutions have still retained the percentage or absolute grading system.

A lot of criticism has existed against this system of marking, probably due to inept application of the assessment methods. We will discuss some of them. The criticism levelled against percentage marking has been that it is seldom possible to achieve the precision of judgement implied by the percentage marking. To quote G. M. Ruch [6]

*"...a large body of experimental evidence points to the fact that from but five to seven levels of ability are ordinarily recognisable by teachers in marking pupils...The difference between a "85" and a "86" is a difference at least five times as fine as the human judgement can ordinarily distinguish"*

Therefore fine distribution of marks may not truly reflect the ability of the learner. On the other hand broad

categories of markings will reduce the wrong marks allotted to the learner, it can also lead to overall reliability [5]. However the two distinct advantages of absolute markings are 1) it clearly relates to the achievement of the individual learner and 2) it provides a fixed and a standard measure of achievement. Thus as compared to relative marking it does not allow allocation of high marks to incompetent students just because they are the best of the bad lot nor is the standard of achievement influenced by the performance of the whole group.

In comparison, the major problem in assigning relative marking is that not all class groups are typical. Thus variations in the ability and achievements of the class groups have to be accommodated before assigning the final grades. The rationale behind relative marking seems to be that the inherent competitive tendencies between the members of a class will cause the mean of performance to be at the desired value. However this is not necessarily true. Other factors such as learner profile, instructors ability to motivate and external factors may not ensure a healthy competition. Many of the low achievers shy away from competition. Even intelligent students may become disinterested in competition. Competitions calls for a certain level of play, rivalry and a need for self-glorification. Highly self-confident and mature individuals may not require satisfaction of such emotional needs and may turn out a lower performance. On the other hand under confident learners may just give up. Hence such assessment will not truly reflect the level of learning in an individual. In addition the instructors' contribution can also distort the marking. It has been found that the instructors tend to give high and a few low marks, [5]. This is due to various factors such as feeling of mercy, to develop favourable reputation for the course and some times to cloak the poor teaching methods. In such cases the purpose of assessment is lost. Such distortions may actually encourage the "learning for exam" syndrome.

Since the process of learning and stages of the learners can be classified, it is possible to assess these with the help of criteria. These criteria are directly related to the criteria of classification for the learner and the process. This brings us to criterion-referenced learning.

### CRITERIA FOR ASSESSMENT

Before we discuss the criteria for assessment, let us briefly look at the classification of the learner profile and the process of learning. To improve the quality of teaching and learning it is very important to clearly describe in detail the performance desired in competent learners at the end of the course. It has been found that, if the instructor has clearly defined the objectives in terms of after-the-course-competence of the learner, the student performance will invariably improve. These post-course objectives in the student behavior have been given as taxonomies. They help organise the objectives in a meaningful way. The different taxonomies show a logical progression from simplest

learning patterns in a novice type learners to complex patterns in a proficient or expert learners. Following are criteria which are common to most of the taxonomies [7],[8] and [9]

- **Associating:** a process of recalling material from memory along with the associations with other material. This may be terms, definitions, data, structures and basic principles.
- **Discriminating:** a process of comparing different ideas. This is reflected in the ability to see differences or similarities between two concepts, or materials in the course.
- **Conceptualising:** a process where the learner forms an organised pattern between the material learned which s/he has already learned to discriminate. This could be termed as defining the problem or seeing the big picture.
- **Valuating:** a process of comparing the attributes or value of one concept to another. This may lead to selection of an appropriate concept over another to satisfy a given problem at hand.
- **Predicting:** ability to forecast the result. Having formed a concept and placed a value on it the learner is now able to apply the concept to other constraints and predict possible outcomes
- **Deciding:** an ability of the learner to select the optimal solution from a gamut of solutions.

This classification matches with the learner profile. The process of learning in a novice type learner starts with associating and discriminating. As the proficiency of the learner improves the learning progresses to higher level of cognitive process. Thus by converting these post-learning behaviours of a learner into criteria of assessment each learner can be manoeuvred from novice to expert. It can be seen that the learning starts from surface and progresses to in-depth learning.

### Criteria based on Engineering Functions

It is one thing to produce taxonomies of assessment but unless they are clearly stated in terms which are tangible to the learners the desired result may not be produced. One of the ways of producing criteria for assessment proposed in this paper is derived from the role of a power electronic engineer. Criterion-referenced assessment was implemented for an electrical engineering elective: Power Electronics. It is a specialist field in Electrical engineering covering a wide range of activities. For example a large number of power electronics engineers are concerned with power supplies in equipment ranging from consumer electronics and business equipment to specialist equipment like lasers, and plasma generation. On the other hand a power electronic engineer may be concerned with control of electric drives from industrial, traction to precision equipment like robotics and CNC (Computer Numerically Controlled) machines.

Moreover, consumer electronics engineers are also required to have some knowledge of the power supplies they use in their equipment. Thus the level of proficiency depends on the role of the engineer. If we just consider power supplies for consumer and business equipment, an engineer working in this area may have a function of sales and marketing. In such a function the engineer would be required to know the basic working of the device, know about norms and permissible operating limits of the equipment, should know about the technologies available in the market. In addition to these the engineer is required to have cross disciplinary skills such as personal communications, economics, finance and commerce. Thus any learner wanting to achieve this level of functionality will not be required to have in-depth and specific knowledge of the working of the equipment s/he is selling. On the other hand the function of a design and development engineer requires a deep and specific understanding of different power supply topologies. Moreover, the engineer will require valuating, predicting and deciding skills. This is not to say that the sales engineer doesn't require these skills. However, as far as power electronics part is concerned it would suffice the sales engineer to know whatever has been valuated, predicted and proposed by the engineering department. The advance skill level of a sales engineer may be in field of commerce, finance and marketing. Identifying the roles of engineers in this field can help us define the criteria for assessment. They are broadly based on the function engineers play in an organisation. sales and marketing, manufacturing and maintenance, quality control and design and development are some of the main functions. The criteria derived from these function are

- **Basic competency:** the student should have the knowledge of the fundamental concepts of power electronic devices ( circuit symbols, typical ratings) and circuits. This includes the working range of devices, the circuit structures and their basic working, waveforms under ideal conditions
- **Analytical competency:** the student should show ability to apply the fundamental concepts to solve problems of power electronic systems
- **Valuating and Predicting:** In-depth understanding of the subject has to be demonstrated such as design of power electronic system, solution of non-routine problems
- **Expert:** demonstrate all above abilities and in addition original thinking, cross-migration of ideas and ability to identify optimal solutions in power electronics.

This method of setting criteria is based on the requirements of the immediate stake holders. They may be the industry or the research and higher education institution. In so doing the criteria have concrete goals which allows for a better teaching and learning environment.

The point to be stressed repeatedly is that the criteria of assessment and the final summative assessment in terms of marks or grades should be made very clear to both the students and the instructors.

### TIMING OF ASSESSMENTS

Marshall [10] best highlights the role of assessment in teaching and learning

*"... that student behavior is conditioned by the assessment process and modifying courses is unlikely to have much effect on study habits if the examinations remain unchanged. Put bluntly, the examinations breed bad studying"*

This line of thought has been the focal point of this paper. At present, students approach examinations with fear and speculation which surfaces as illness or frenzied activity. On the other hand for instructors examinations are associated with disappointments and frustration. The end of the semester exams and assessments are approached by both students and instructors with a certain amount of speculation. It has been found that students often study for the end of semester exams and the portion covered is often large. There is less time for revision. Formative assessments do not necessarily solve the problem of having to learn everything at the end. In order to remove the speculative nature of the end of semester exam periodic assessment can be used. These assessments could be formative or both formative and summative. The whole idea being

- even work load: to spread out the required effort over the semester
- focused study: to concentrate on specific topics, learn less but learn well
- reduce stress: give students an opportunity to monitor and improve their performance, use the assessments as "carrots" rather than "sticks".

Some of the lecturers find it difficult to digest the idea of no final exam. They may be right especially if the learners are not given an opportunity to put all the concepts into a bigger picture. In many courses it is required to get the whole picture. Here the role of the final exam is vital. However, while giving such an exam the purpose of the examination should not be forgotten. At this stage the examination is to assess the ability of the learner to get the complete picture from the bits and pieces mastered during the course. It is not to reevaluate all the specific bits and pieces. Thus, the nature and the timing of assessment should be tailored to satisfy the goals of the course.

### CASE STUDY

Thus far the paper has highlighted the problem of assessment and how it can be used or misused. A specific course was selected to implement the ideas put forward in the paper: the application of continual and criterion-

referenced assessment to enhance in-depth learning. The course selected was the 3rd year elective in power electronics taught by the author. A class of 23 was offered continual and criterion- referenced assessment. The criteria were defined according to the role of the power electronic engineer. Each criteria was explained to the students at the start of the course. The post-course behaviour or the expected outcome from the course was also made clear to the students. As the course covered a broad spectrum of power electronics, five major areas were identified. The importance of these areas was decided on the basis of the most likely areas of employment of the successful candidates. The course was divided into five contiguous segments and the students were informed that they would be tested after each of the segments. They were also informed that they had to pass each of these segments. Tutorial assistance for each of these segments, including questions was made available to the students through the World Wide Web (www). The tutorials served as practice or preparatory material for the tests. Each test mark was added to the final assessment. The total assessment would include 70% of the test marks to which 30% was added from the performance in the laboratory. The laboratory consisted of four experiments designed to match the distinct course segments. The students had to perform the laboratory exercise depending on the hand-out given to them. The assessment was to test the students ability to observe and explain the phenomena in the experiment. It would also assess the ability of the students to explain the observation by correlating with the information learned in the lectures. The laboratory assessment was not aimed at testing the communication skills as it was felt that the students were subjected to this assessment in the other courses.

### Goals of the periodic test

One of the main goals of the test was to even out the workload over the semester and to avoid end of the semester "cramming". This allowed the student to concentrate on the specific topics already defined. By setting the test to satisfy the assessment criteria another important goal was addressed to induce in-depth learning. Moreover, the students were not tested for speed. Thus a conscious effort was made to see that the test could be answered in 30 minutes. The students were allowed 2 hours to answer and meditate on their answers. The 2 hour block is the standard lecture/tutorial block of time allotted in the department time -table.

In addition the test served also the purpose of helping students monitor and improve their performance. The tests were marked and commented. Each student was given opportunity to go over the corrected test papers and discuss the results with fellow students. The students were also encouraged to discuss ways of achieving high performance with the lecturer. After each test the student was shown the level of performance achieved and how far s/he was from the next higher scale.

**QUANTIZATION OF CRITERIA**

Many Universities still allot numerical grades based on percentage of marks obtained by the students, Table I. This is known to students. The whole idea was to quantize the criteria such that the student could be given percentage marks for satisfying the standards of the criteria and these marks could be expressed as grades.

TABLE I  
GRADING SYSTEM USED BY THE UNIVERSITY

Grades	1	2	3	4	5	6	7
Range of marks	0-19	20-44	45-49	50-64	65-74	75-84	85-100

Setting the test to match the criterion-referenced assessment is a complex task. In fact writing a good test requires hard work and a lot of time. There are several guidelines on developing a blue print of a test, [11], [12]. The most common method is to prepare a table listing the level of cognitive complexity and the concepts to be covered. The levels of cognitive complexity are derived from Bloom's taxonomy, [7]. One such table is given here. It reflects the structure of the test used in the course on power electronics

TABLE II  
SETTING A TEST TO SATISFY CRITERIA

	Topic 1	Topic 2	Topic 3	Topic 4	Topic 5
Knowledge	x	x	x	x	x
Comprehension	x	x	x	x	x
Application	x	x	x	x	x
Analysis	x	x	x		
Synthesis		x	x	x	
Evaluation	x	x		x	

Since it was decided that the final assessment would be a form of grading as per Table II, it was necessary to determine the percentage of marks given to satisfy each criteria. For the course in question the following pattern was used

Basics, definitions and notations, tools -of-trade	45%
Analysis and routine problem solving	30%
Non-routine problems and simple design	15%
Original thinking, cross-migration, optimal solution	10%

This maps the matrix of the criterion-referenced assessment to a single column vertical structure. The standards of achievement are quantified as marks corresponding to a particular criteria. In doing so the students were able to monitor their progress in terms which they were comfortable with.

**EVALUATION**

Teaching and subject evaluations were performed at the end of the course. The responses to some of the questions

relating to the mode of teaching and learning were encouraging.

To question as to whether the students were responsible for their own learning the students responded as

strongly agree	33%
Agree	62%
Uncertain	5%

To question whether the students had learned to think critically the response was

Strongly agree	20%
Agree	60%
Uncertain	15%
Strongly disagree	5%

On whether they had an opportunity to demonstrate what they had learned in the course they responded

Strongly agree	19%
Agree	52%
Uncertain	29%

On whether thinking was emphasised rather than memorising, the responses were

Strongly agree	52%
Agree	38%
Uncertain	5%
Disagree	5%

On whether the course helped improve students learning skills

Strongly agree	33%
Agree	38%
Uncertain	14%
Disagree	14%

Some of the comments from the subject/teaching evaluation feedback are able to point out the advantages and disadvantages of this method

*"continuous evaluations definitely work better than having exams"*

*"Usefull practical Lecture notes extensive"*

*"Lecturer gave us lots of small tests which in turn gave feedback though sometime with two subjects with small test it did start to become 'painful' especially when they come in the same week"*

*"The assessments (5 tests) should be reduce(d). It is too time consuming. I spent a lot of time studying for tests. Not denying that getting a good grade be easy but other subjects are neglected. There should be only 3 tests"*

*" The continue(sic) assessment is an effective way of testing the students. Though it may be very time consuming at times, but they learn much more this way*

*-students can also judge by the tests how much effort they can put in the next test*

*-and this way also reduce the student load at the end of the semester when coming to - the exam*

*-Overall this system should be implemented for this subject only because if it is an exam the work load with things to remember is really too much for students"*

*"OK the continuous assessment was great, since it only happened in one subject. Too many subjects with continuous assessment would create too much work load"*

*"A lot of thinking for students"*

*"The lecturer has endeavoured to make sure students have an understanding of the subject as opposed to just knowledge. Continual assessment is much fairer, and gives the students the opportunity to familiarise themselves with slightly unusual exams (ones that require original thinking)"*

*"Practical, wants students (to) learn material rather than just pass tests"*

*"-Stimulate student to think constantly*

*-“understanding not memorizing”*

### SUMMARY

Assessment has a great influence on learning habits of the students. The timing as well as the type of assessment can be used to enhance the learning patterns, 71% of the class seem to agree that there was an improvement in the learning skills, whereas 90% of the class agreed that they were encouraged towards thinking rather than memorising. About 95% of the class felt they were responsible for their learning. An other side effect was there were only two special considerations for medical reasons, as compared to five last semester. In the previous semester the course had an end of semester exam and norm-referenced assessment.

However, it was found that too many tests would undermine the purpose of continuous assessments. This could drive the students towards "learning for exam" syndrome. The method of assessment also did not allow lateral progression. Since the grading and the criteria were vertically structured some of the students were disadvantaged. This is because not all students will be comfortable with the test assessment format. It was found that students should be able to satisfy the assessment criteria through a delivery system they are most comfortable with. In order to reduce stress due to continual summative assessments corrective assignments were offered. This was primarily targeted for the low achievers. The low achievers had options to show that they had satisfied the criteria in any of the segments by either submitting a simulation of the basic circuits discussed in the segment or by solving and submitting a set of problems related to the topic. In such case the student could only come up to a Pass level. However, similar optional methods can be made available to the students for other criteria. In conclusion the steps to be taken to mitigate the problem of examination anxiety and work load are

- equalise the portion of the syllabus associated with each segment/test without compromising on the quality of content,

- produce pre-test sessions to direct the effort towards effective learning, and
- strive to create a stress free atmosphere in relation to the assessments by providing remedial or optional assessment methods.

The case study presented was one approach to induce in-depth learning. However, assessments cannot achieve that in isolation. There are two opinions about how learning can be improved. One school of thought says that learning attitudes can be changed by changing the curriculum and the method of delivery whereas the other says that learning outcome can be changed by assessments. However, a study carried out by Walker and Schaffarzick [13] shows that the success of the tests is high when there is a very high correlation between the type and content of the test and the curricula. This shows that on one hand the type of assessment is not a sole motivating factor influencing the learning strategies while on the other hand it also shows that the curricula or the method of delivery does not necessarily equip the student to take on any form of assessment. In order to avoid such pitfalls it is important that an integrated approach will be taken towards desired learning outcomes.

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