

## Assessment of Lab Work: A Three-Domain Model; Cognitive, Affective, and Psychomotor

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### Abstract

Several models exist for assessment of lab work. One depends only on written reports in lab notebooks during lab time. Another depends only on written reports after the lab is done. A third adds to after-lab written reports an exam component. In this communication, we provide an educational model to analyze the lab work educational experience. This model depends on the three domains of human behavior; cognitive, affective, and psychomotor domains. It also draws on the information-processing model of education. This three-domain model (TDM) helps identify the educational elements comprising the lab work. Therefore, it leads to a properly structured assessment plan. Lab skills including safety, breadboard techniques, equipments handling techniques, measurement techniques, analysis and logical development of student work, notebook reporting, and formal reporting are some of the identified elements of the educational lab experience. According to the identified elements, an assessment plan is devised and implemented. It leads to a very well structured method with maximum objectivity and minimum subjective characteristics. Checked lab work, notebook and formal reporting, and a practical test with the use of a graded checklist provides the most objective assessment of the student education in conjunction with the developed educational objectives. The TDM model is easily applicable by electrical engineering educators through a step-by-step algorithm that is provided. It is equally applicable to other engineering, and non-engineering, disciplines, that use lab work as an educational tool. The presented algorithm and model both can contribute greatly to the education of electrical engineers. It is used by the author in actual lab environment with positive contributions to the student education and ease of management of the education environment.

### I. Introduction

Lab work is a very important component of electrical engineering and electrical engineering technology education. For the student to have a good rewarding educational experience in the lab, this experience must not only be properly designed and integrated

with the lecture. A proper assessment must be planned and fairly executed. Part of the frustration, on the side of the student, with the lab experience is what is usually referred to by students as unfair grading.

Educationally, this may be attributed to the 'blue eyes method' of assessment where two students do the same job and receive different grades.

In this communication, we review a couple of the most popular methods, models, of assessment of lab work. An educational model based on the three domains of human behavior is then discussed. This leads to the identification of the lab skills to be developed by the student through the educational experience, independent of the specific material covered by the lab work itself. An assessment plan is then developed with detailed discussions. We close by presenting a step-by-step algorithm that details the steps to apply to achieve an educationally proper assessment plan for lab work. This algorithm is equally applicable to electrical engineering, to electrical engineering technology, to other engineering disciplines, and to non-engineering disciplines that use lab experiences in education.

## II. Popular Models of Assessment

The three most widely used models of assessment of lab work in electrical engineering education today, and for quite some time, have a large component of subjectivity and do not measure all the components of the educational lab experience.

The first model of assessment is based only on reports written during the lab in the notebook. An assessment based solely on written material has more emphasis on verbal communication skills than lab skills itself.

Another drawback is that students can copy the written materials and get credit for no education on their part.

In short, this model assesses only one part of the educational lab experience and missing the most important components to assess, as will be addressed later in this communication.

The second model of assessment is also based on written verbal communication only. In this model what is assessed are reports written after, not during, the lab. Again, it misses assessing the essence of the lab work, which is the lab work itself. In addition, it misses the verbal communication during the lab, too.

The third model is actually the second one with an added component; a practical exam. This added component of assessment, when properly considered, is an essential one because it makes sure that the student can do the job himself; experimental investigation.

This model still lacks a lot of components to provide adequate assessment of the student educational experience. These missing components are addressed in the following sections.

### III. Educational Three-Domain Model (TDM)

To properly analyze the lab educational experience, one needs to apply the three-domain model (TDM) to this experience. This leads to a breakdown of skills related to each domain. With the knowledge of the skills and the associated domain(s), an assessment plan logically follows.

- i. *Cognitive Domain.* The cognitive domain is the one where the student's cognitive activities are structured. Starting with the knowledge level and ending with the evaluation level of Bloom's taxonomy, this domain is used to analyze the lab experience of the student.<sup>1</sup>
- ii. *Affective Domain.* The affective domain is the one that describes the attitudes of the student toward the subject matter, education, and lab activities. This domain is very important in setting the ground rules for the lab environment. It greatly affects the student performance and education without being clearly visible.<sup>2</sup>
- iii. *Psychomotor Domain.* The psychomotor domain is especially important in the lab work. It describes the coordination between the student's brain and body. Obviously, this is an important domain in relation to the lab environment.<sup>3</sup>

Information Processing Model (IPM). This relatively new educational model that stemmed from the application of artificial intelligence concepts into education has drastically changed the theories of learning over the last decade.<sup>4,5</sup> It relates the learning process to knowledge structures developed differently by each student. In essence, it redevelops an ancient Greek theory of education in light of recent developments of modern artificial intelligence concepts and models. This, in turn, explains and outlines the individual nature of learning styles.

When the above mentioned TDM model, in conjunction with the IPM model, are applied to the lab component of electrical engineering education, the following lab skills are identified. These skills are to be mastered by the student through the lab experience.

### IV. Lab Skills

The following lab skills are related to the TDM model; cognitive (C), affective (A), and psychomotor (P).

*SAFETY (CAP).* Safety is the one most important skill that all students should develop and maintain during their lab experience. This skill spans the cognitive, affective, and psychomotor domains. It has a cognitive component where a student comprehends the processes involved and learns how to develop his own in the future. It has an affective component where a student has to reach a mature understanding and comprehension of the concept of safety, and understand that safety is an issue associated with his presence in the lab environment. It has a psychomotor component where the student has to master all safety procedures in handling electricity, components, and equipment, taking account of the environment he is in and the others involved in it.

*Breadboard Techniques (CP).* Breadboard techniques are part of the student lab experience and skills he needs to master. Proper layout, wiring, and connections require an effort on the side of the student to develop proper techniques with help of the educational experience. This can affect, either way, the results and outcome of his experience.

*Equipment Handling (CAP).* Equipment handling is another skill to be mastered through lab educational experience. It involves the three domains; cognitive, affective, and psychomotor.

*Measurement Techniques (CP).* Measurement techniques are part of skills to be mastered by the student. Measurement techniques are to be developed over time and should be addressed as an independent issue in lab work. They are to be applied in varying lab conditions and requires special attention by the student and the instructor.

*Analysis and Logical Development (C).* Analysis and logical development of student work is a skill that spans the cognitive domain. Students left to themselves cannot develop adequate tools for this skill and are subject to diverse miss conceptions. Continuous development and shaping of this skill with the help of the instructor and properly design lab activities should receive special attention.

*Notebook Reporting (C).* Notebook reporting during the lab period is an overemphasized skill in the lab experience. When it comprises the whole student grade for his lab experience, this is an overemphasis. Of course, it is one, and only one, of the skill. It provides a vehicle for the student to report on his lab learning experience, and for the instructor to better evaluate the student educational achievements.

*Formal Reporting (C).* Formal reporting should be, and is not always, part of the lab skills. As ABET consistently points out, the formal reporting is a necessary skill for electrical engineers in today's, and tomorrow's, job market that most curricula neglect.

## V. Assessment Plan

When the above discussed lab skills are identified, educational behavioral objectives are to be written and associated with each of the TDM model domains. This facilitates the design and implementation of a proper assessment plan. This plan will have the following positive educational characteristics;

- i. *Well Structured.* The first important characteristic of a successful assessment plan is structure. In itself, this reflects a well structured educational experience that the students goes through to get a good education. It eliminates lots of frustration and miss conceptual education on the side of the student. And, it helps the instructor manage the educational environment more effectively.
- ii. *Maximum Objectivity.* An assessment plant with maximum objectivity provides a proper educational experience for the student, and easily assessed educational achievements for the instructor. It also provides for a fair grading system; assessment.
- iii. *Minimum Subjectivity.* This characteristic of the assessment plant is exactly the opposite of the previous one. It leads to the same advantages for both the student and the instructor.

*Plan Elements.* The following plan elements are obtained using the TDM model and the developed lab skills discussed in the previous sections.

- i. *Checked Lab Work.* The whole experiment, or part(s) thereof, are to be checked in each and every lab during the lab period itself. The instructor is to make sure that the student can, and did, do the experiments himself.
- ii. *Notebook.* The note book is to include all pertinent info to the work done in the lab. Standard, and personalized, written communication skills are to be checked for mastering by the student. The fact that the student does this type of communication by himself during the lab period is one that needs to be stressed and encouraged.
- iii. *Formal Reports.* The writing of formal reports, using the lab notebook, is a third component of the assessment plan. It needs to be addressed properly by the instructor during the lab course with proper emphasis. This component cannot be over emphasized.
- iv. *GRADED CHECKLIST.* A graded checklist (GTL) is a proper educational assessment method. This GTL includes the rest of the lab skills to be assessed by the instructor. It includes *SAFETY, Breadboard Techniques,*

*Equipment Handling Techniques, Measurement Techniques, and Analysis and Logical Development.* A grade, out of ten, is given for each of these skills during each lab period. At the end of the semester, a wealth of information on the student educational development is available to make his grade in a very detailed and objective way. The use, and sharing with the student, of this GTL ensures proper education, grading (assessment), and feedback.

v. *Lab Practical Test.* This test, properly designed and executed, to assess the achievement of the set aims and objectives of the course always proves very useful educationally. It is best done in the so called dead week of the semester, or the week before. This way it achieves its educational objectives and does not interfere with the finals of the semester educationally or administratively.

## VI. System's Approach

The use of the developed assessment plan in evaluation and redesign of the lab course is the next step. The proper execution of the designed assessment plan evidently leads to better evaluation, and consequently better redesign, of the course. This in turn will lead to an improved assessment plan the next time around. And so on. This system's approach is a powerful educational approach to employ.<sup>6</sup>

## VII. Step-by-Step Algorithm

The following algorithm is a step-by-step approach to develop the assessment plan for the lab work for any discipline that employs lab experiences in education, be it electrical engineering, electrical engineering technology, engineering, or non-engineering.

- a. *Analyze* the educational lab experience(s) by use of the TDM model, taking into account the IPM model.
- b. *Determine* the involved lab skills. The ones discussed above serve as a starting point.
- c. *Write down* the educational behavior objectives for the lab experience(s) and relate them to the cognitive, affective, and psychomotor domains.
- d. *Design* the assessment plan in detail.
- e. *Implement* the designed assessment plan.
- f. *Perform* an evaluation of the course.

- g. *Redesign* the assessment plan using the outcome of the evaluation.
- h. *Go through* the system's approach cycle.

## VIII. Conclusions

An educational three-domain model of lab work assessment is presented; cognitive, affective, and psychomotor domains. Its application to electrical engineering, and electrical engineering technology education provided a list of lab skills for the student to master by a lab course. A detailed assessment plan is then developed that is very well structured with maximum objectivity and minimum subjectivity. We closed by an easy to follow step-by-step algorithm that could be used by educators in all fields that employ a lab component. The use of the system's approach is recommended to improve on the assessment plan design and implementation leading to a better education of students. The discussed assessment plant is already used by the author with great success and student acceptance.

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