



## EVALUATION PROTOCOLS IN SCIENCE LABORATORY LEARNING THROUGH ICT TECHNOLOGIES

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### ABSTRACT

*Science Laboratory learning using ICT, evaluation protocol is an important part of quality of assurance and to provide feedback for teaching and learning. Virtual lab is widely used ICT technology for the last five years to assist new faculties in science. In this study, we focus the purpose of assessment and raising various difficulties associated with current evaluation techniques in learning and teaching. Assessment is based on test which includes different types of questionnaire for undergraduate students (N=150). Index of learning is conducted among these students, identified reflective and non-reflective learners. From our results, it is difficult to assess student's knowledge gained from traditional or virtual classroom environment from single questionnaire protocol, especially for Visual-Verbal aspects in MCQ approach. Essay type questionnaire and Yes/No questions, the method is constrained to find solutions. We also discuss dependable factors and its percentage affecting for different questionnaire. The Cronbach's alpha value is high for descriptive type questionnaire rather than MCQ, which show internal consistency, is high for descriptive type. T-test is conducted for the variation from one type questionnaire with combination type questionnaire. Current evaluation method does not fulfill the actual goals and this will lead to even misleading the assessment criteria rather than what they gained.*

### INTRODUCTION

On-line platform for science learning creates a challenging environment among undergraduate students. Due to covid-19 pandemic situation, educational institutions/universities mostly prefer online learning platforms to meet the requirements for graduation. Many studies conducted in the past for the enhancement in learning and education through ICT technologies [1-2]. Hence raise the question that what are the evaluation methods required for the proper, valid results in learning assessment. Oliver (2000) developed a strategy to evaluate the use of technologies in education. To understand more about learning as well as teaching, assessment protocol is essential [11]. Proper laboratory learning is an integral component in science education [9-10]. Continuous assessment helps to evaluate a learner's understanding and knowledge about the subject even if they having different abilities

[15]. Definitely ICT enabled laboratory learning like animation, simulations and videos which the experiment is described can provide deep understanding about concepts, experimental procedure and make it more interesting one to students[1,12-13]. In this study, we are not following traditional experimental laboratory, but focusing ICT enabled experiments using virtual labs and checked current assessment methods/protocols/criteria is sufficient or not in science laboratory learning.

The three main purposes for assessment include (1) decision making (action), (2) evaluation for conceptual understanding and (3) measurement of cognitive load and skills [4,5,6]. Determining student's attitude towards problems is usually difficult to evaluate [8]. An important requirement is the type of questions raised for finding a particular answer. In science learning, laboratory based assessment cannot



be generalized in one type of questionnaire hence we are opting types of questions and try to find out an effective method for the current evaluation scenario.

### METHODOLOGY

This study is carried out under MHRD project in collaboration with titled Virtual Labs (<http://www.vlab.co.in>). Here purposive sample N=150, undergraduate science students from Mahatma Gandhi University were taken to perform four science virtual lab experiments, two each from Electronics and Mechanics Virtual labs.

The students were selected based on their academic results and they do not have experience in real lab environment. Assessment is based on test which includes different methods of questionnaire. The

|   |  |
|---|--|
| 1 | Sensory: go through the fact<br>Intuitive: try to understand the meaning   |
| 2 | Visual: prefer for visual representation<br>Verbal: prefer explanation with words  |
| 3 | Active: prefer group work and try to figure out problems.<br>Reflective: try to find out a solution                      |
| 4 | Sequential: overall understanding not into depth.<br>Global: firstly try to understand the basics and then find solution |

Here we used traditional classroom and virtual lab environment, and try to teach these experiments effectively for students. Index of learning is evaluated by using multiple choice questionnaires (MCQ), most of the students prefer Visual-Verbal learning styles (N-92), Sensory - Intuitive (N-11), Active - Reflective (N-10), Sequential - Global (N-39). Here also it is found to be difficult to prepare single type questionnaire to assess all the four aspects in learning styles.

### Phase II

After teaching, allowed the students for doing real lab and virtual lab. Assessment is based on test/exam which includes different types of questionnaire. For this phase rather than learning styles, we try to evaluate the depth of knowledge gained from traditional and virtual classroom. The questionnaire is prepared covering four experiments as total 45 questions includes 20 MCQ questions (1 marks), 10 descriptive questions (5 marks), 5 essay type questions (10 marks), and 10 yes/no questions (1/2 marks). All the questions are prepared by making criteria that, to find the solution for one problem, questions are from all four different types. Example: To measure the conceptual learning about ohms law, questionnaire is prepared as follows  
 Eg: MCQ: What is the ratio of voltage and resistance?  
 Descriptive: What is ohms law?

tests were carried out after performing the experiments in Virtual environment. These assessments can be also used to measure the knowledge attained by the students from virtual environment.

This is to identify which test is most convenient for the student's evaluation and what are the drawbacks if we use one particular method like Multiple Choice Questions (MCQ). The student's performance cannot be assessed by single method, if some have ability to solve particular type of approach.

### Phase I

- According to Index of learning model, the four dimensions of learning styles [14], we divided the students into four groups.

Essay: Explain ohms law using circuit diagram with examples?

Yes/No : Voltage in circuit can be calculated if current and resistance is known ?

The questionnaire based assessment is conducted after real lab and virtual lab, each type of questions is individually tested and analyzed among students.

### RESULTS AND DISCUSSIONS

From Fig 1 & 2, simulations using virtual environment allow students to control the parameters of the experiment to get maximum knowledge and can attain more about the concepts with application level. Score attained by the students increased in virtual laboratory. Most of students irrespective of their learning style, scored well (<80%) for all types of questionnaire in virtual environment. From our results shows that both real lab and virtual lab, students gained well score for descriptive and essay type questions but low marks in MCQ for the question which is asked in different type. It clearly indicates that understanding and depth of knowledge cannot assess by only using MCQ approach. Yes/ No questions are not a valid type of evaluation method for science learning. To measure the internal consistency/ reliability of the questionnaire, we tested cronbach's alpha. The results are shown in the table given below



| Type of questionnaire | N  | Sum of item variance | Standard deviation(SD) | Cronbach's alpha | SEM  |
|-----------------------|----|----------------------|------------------------|------------------|------|
| MCQ                   | 45 | 1.65                 | 1.44                   | 0.45             | 0.08 |
| Descriptive           | 45 | 1.95                 | 0.89                   | 0.76             | 0.06 |
| Essay type            | 45 | 1.55                 | 0.75                   | 0.58             | 0.09 |
| Yes/No                | 45 | 0.24                 | 0.4                    | 0.01             | 0.1  |

The alpha value is high for descriptive type questionnaire rather than MCQ, which show internal consistency, is high for descriptive type. This may due to some of the facts that,

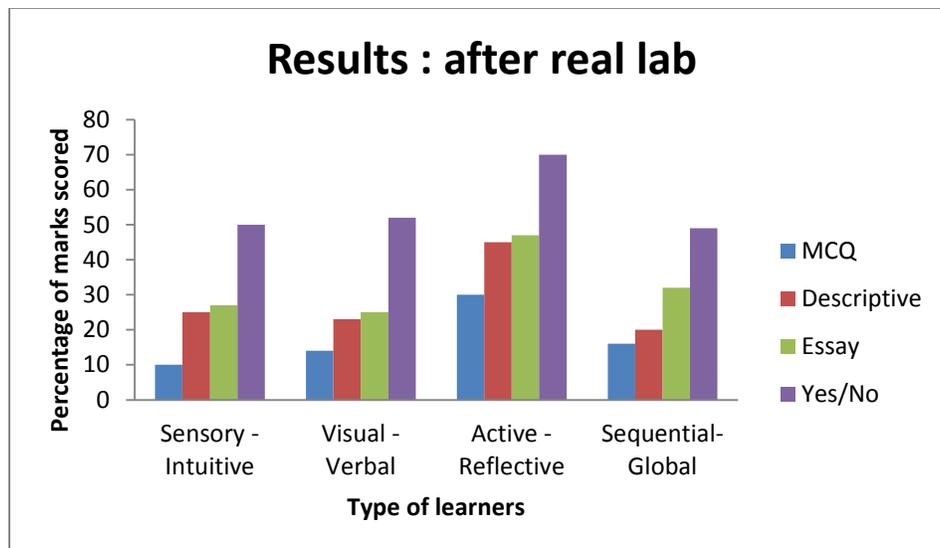
MCQ test, students are asked to answer from options given even if they can answer randomly. This type of questions will be useful only for problem solving. But broad coverage and infinite sampling can be done by using this type of questionnaire. But major drawback for this method is that teachers cannot test knowledge based on theories and depth of knowledge. There is also a possibility for the students who can guess appropriate answer to the question.

Descriptive type questions are used to understand the procedure to the problem. Step by step evaluations can be done for this type. Good

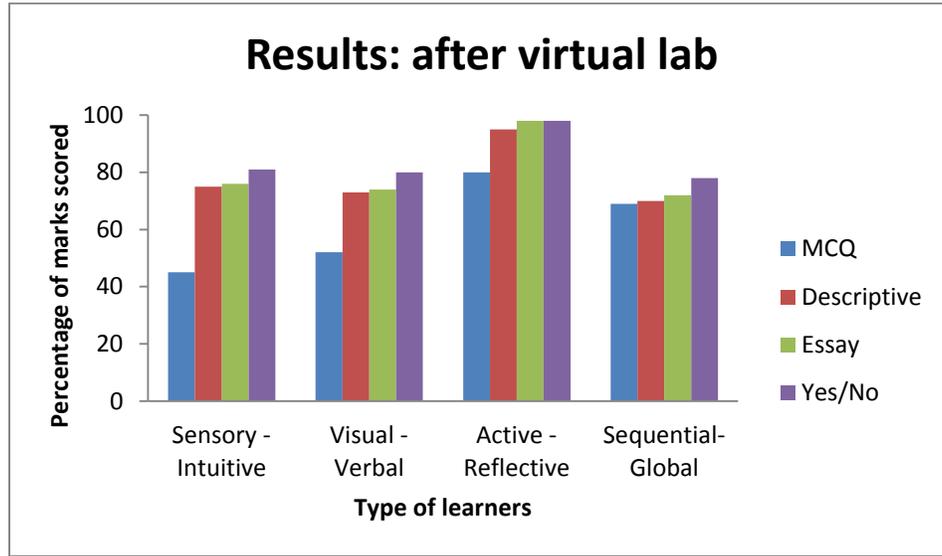
explanations, writing skills, depth of knowledge can be easily understood. It is a time consuming method and students with high memory capacity can have a tendency to gain maximum scores by this questionnaire.

Essay type questions are similar to descriptive type, time consuming helps to evaluate the general idea called open ended type questions. Here learning skills cannot be calibrated especially for laboratory work. Students can answer the questions easily with a very few constraints.

Yes/No questions where students can accept or decline the answer, not a method to evaluate deep knowledge due to lack of content. Questionnaire itself is a restriction and not at all met assessment criteria.



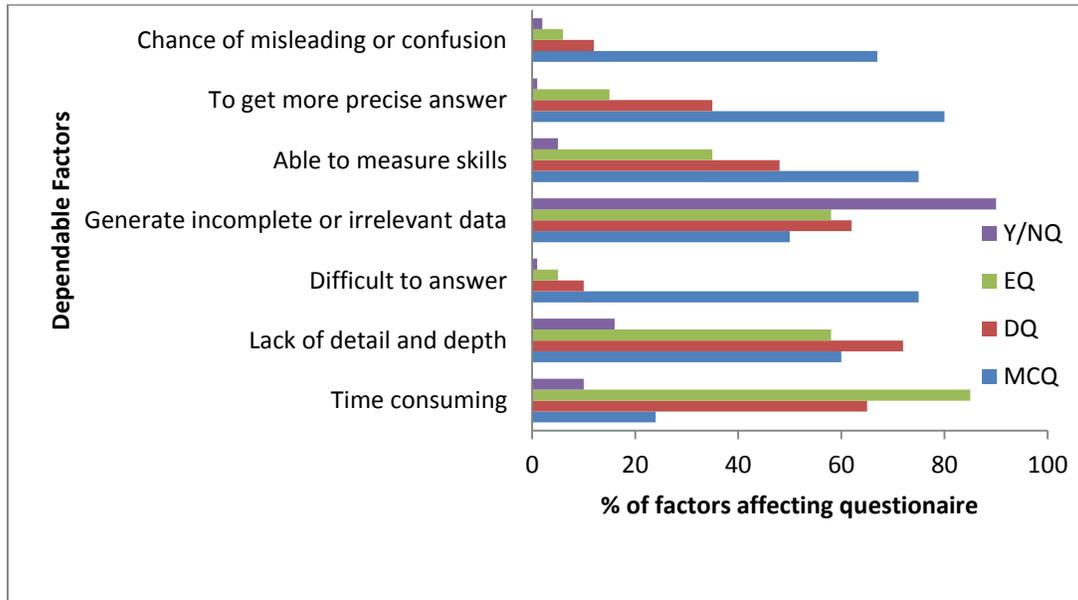
**Figure 1. Results for different type questionnaire for Electronics & Mechanics after real lab**



**Figure 2. Results for different type questionnaire for Electronics & Mechanics after virtual lab**

From instructors point of view, factors that are dependent on the evaluation of students from their academic results (Fig 3). Most interesting factors are

included at which the evaluation may show difficult due to improper assessment pattern to achieve their goals.



**Figure 3. Dependable factors and its percentage affecting for different questionnaire**

The questionnaire which includes only MCQ (mostly problem based questions), the students who have the ability to find the final answer gained scores. The descriptive questionnaire is based on problems by here we allow the students to allow step by step procedure to find final answer. Essay type questionnaire, here we allow the students to explain the

problem with concepts rather simply studying the equations. Yes/No question, this method constrained for the students and there is possibility to get right answer by random selection.

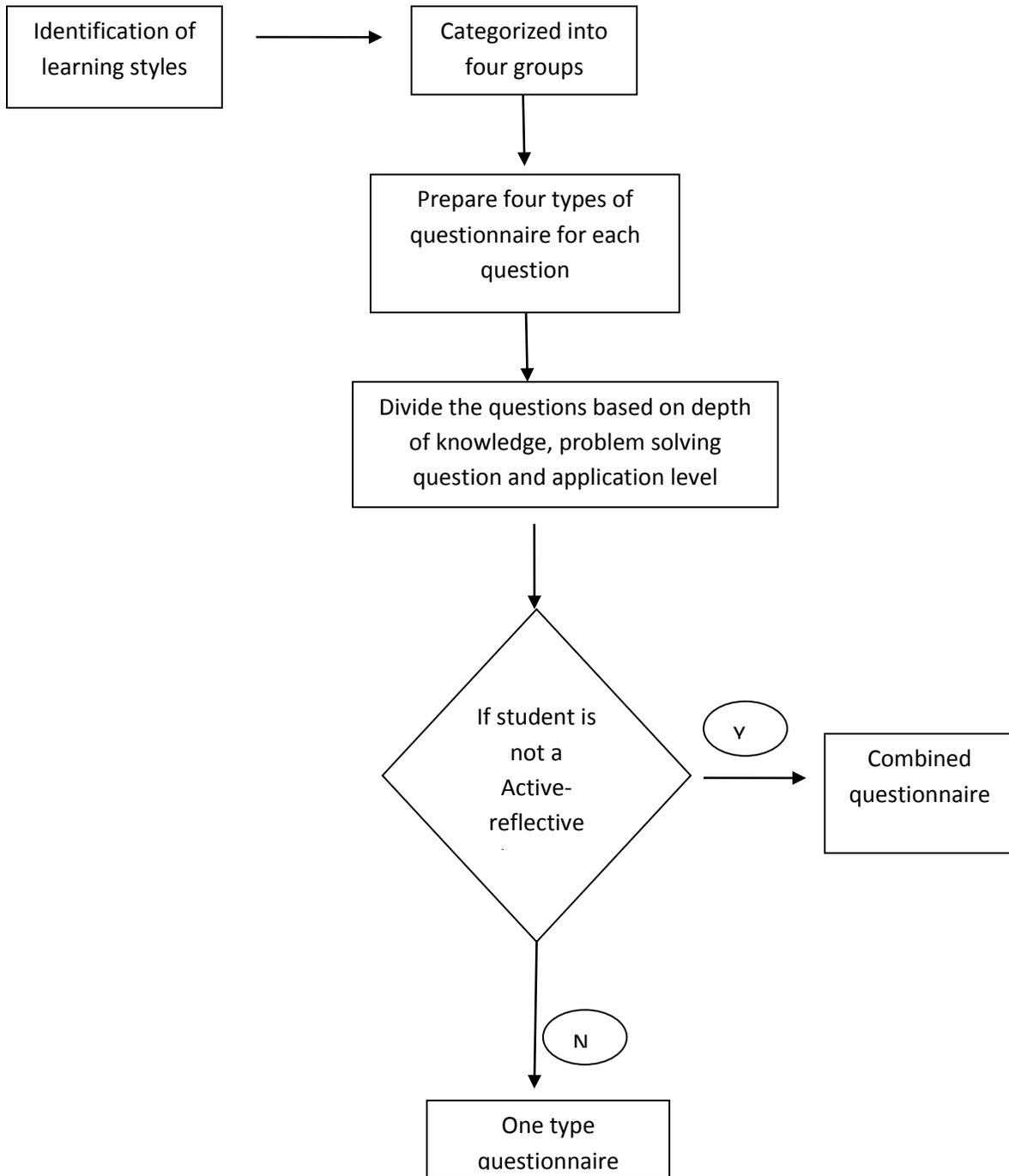
We have conducted t-test which shows the variation from one type questionnaire with combination type questionnaire.



| Experiment  | Comparative study                                  | Mean Scores | t value | P value |
|-------------|--|-------------|---------|---------|
| Electronics | MCQ - MCQ +  | 5.523 8.524 | -13.532 | 0.000   |
|             | Descriptive+Essay+Yes/No<br>Descriptive - MCQ +    | 3.541 8.101 | -8.353  | 0.000   |
|             | Descriptive+Essay+Yes/No<br>Essay - MCQ +          | 3.011 7.425 | -7.154  | 0.000   |
|             | Descriptive+Essay+Yes/No<br>Yes/No - Essay - MCQ + | 1.245 7.989 | -4.899  | 0.000   |
|             | Descriptive+Essay+Yes/No                           |             |         |         |
| Mechanics   | MCQ - MCQ +  | 4.985 8.243 | -11.429 | 0.000   |
|             | Descriptive+Essay+Yes/No<br>Descriptive - MCQ +    | 3.758 8.452 | -7.436  | 0.000   |
|             | Descriptive+Essay+Yes/No<br>Essay - MCQ +          | 3.622 8.128 | -6.434  | 0.000   |
|             | Descriptive+Essay+Yes/No<br>Yes/No - Essay - MCQ + | 0.985 7.975 | -4.140  | 0.000   |
|             | Descriptive+Essay+Yes/No                           |             |         |         |

Our results shows combined questionnaire can analyze and is to dig the learning knowledge of each student. Hence we suggest an evaluation protocol for

the assessment in learning and teaching based on flowchart



## CONCLUSIONS

From our results, current evaluation method does not fulfill the actual goals due to incomplete questionnaire. This will lead to misleading the concepts behind the experiment for students rather than what they gained. Most of the evaluation used one type of

questionnaire, easy to express their opinion or appears as difficult. Most of the assessment takes limited time and will be a problem if the students are at the risk. From our studies, whatever is the assessment method, questionnaire itself should be asked in different form, where students have an opportunity to answer fully by



selecting their easy type. Hence preparation of combined questionnaire in the protocol can analyze the depth of understanding knowledge among students especially no reflective learners and teachers in science related education.

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