Title	Science practicals in schools: Are we assessing correctly?
Author(s)	Toh Kok Aun & Chia Teck Chee
Source	*Singapore Journal of Education, 8*(1), 76-79
Published by	Institute of Education (Singapore)

This document may be used for private study or research purpose only. This document or any part of it may not be duplicated and/or distributed without permission of the copyright owner.

The Singapore Copyright Act applies to the use of this document.

Science Practicals in Schools: Are We Assessing Correctly?

Toh Kok Aun
Chia Teck Chee

ABSTRACT

Traditional practical examinations serve the purpose of ensuring that a candidate has some grounding in practical work. Regretably, however, they fall short in the promotion of process skills. A study done at the Institute of Education shows little relationship between tests which highlight these skills and the traditional practical tests. In today's context where emphasis should be placed on process rather than product, the continued dependence on traditional practical examinations does not seem to be in keeping with current curricula changes.

Introduction

The laboratory has for a long time gone hand-in-hand with classroom teaching as an integral part of science education. In the sixties and the seventies, the era of curricula reforms, the emphasis was on the processes of science with increasing importance given to the use and mastery of higher cognitive skills. Now the role of the laboratory is no longer the same. Conventional ideas and practices on the use of the laboratory as a place for demonstration of science phenomena and the confirmation of well-established laws no longer hold (Shulman and Tamir, 1973). The emphasis is now on highlighting science as a learning process and the process skills that characterize science as a rational, analytical, "scientific" human activity.

Along with this change of emphasis in the laboratory learning situation is the related problem of seeing to it that these learning methods find their way into assessment procedures. Different styles of assessing student mastery of laboratory skills have been attempted, with no one style being universally accepted. The most common style involves the laboratory practical examination — a technique used by several examination boards in the U.K. and Israel. Paper-and-pencil test items (Doran, 1978) have also been used and so are on-going observational assessment (Lunetta et al., 1981; Ganiel and Hofstein, 1982), the latter being formally used in the United Kingdom by some examination boards (University of London, 1977; J.M.B., 1979).

In Singapore recent curricular changes in science initiated by the Curriculum Development Institute of Singapore have also emphasized the importance of process skills. However, the consequent need for teachers to reorientate the methods of science instruction and the nature of student learning experience that are intended to be process-oriented have still to make their impact in laboratory investigations. In this respect the pivotal influence of the existing practical examinations in determining the extent of change is perhaps far greater than anyone would care to admit.

The existing practical examination in Singapore at the 'O' Level (which is determined by papers set at Cambridge University) still has as its objective the testing of whether the candidate's knowledge is firmly grounded in experimentation. While this broad objective does serve to ensure that laboratory work is carried out in schools, it is not sufficiently specific about the process skills that should be emphasized. In fact it is difficult to assess a pupil's mastery level in a particular skill by means of the existing practical examinations. For example, it is not always possible to check that pupils have performed all the necessary manipulative skills correctly during the practical examinations because this is not reflected in the pupil's written report of the practical examination.

This inadequacy could be attributed to the fact that the evaluation of performance in the practical examination is based on the written report (basically a tabulation of observations/results obtained, followed by analysis/deductions made from it) of the candidate. What the written report does not provide is direct information on the candidate's skill in manipulating equipment, and the organising and performing of an investigation in an innovative manner. The written report may offer indirect evidence of mastery of certain skills (Lunetta et al., 1981) as when readings tabulated are obviously out of acceptable limits, but it cannot be generally taken as indicating the quality of performance of practical tasks (Eglen and Kempa, 1974). The quality of performance at practical work should take into account the different process skills involved, viz.:

(a) Experimental Set-up (includes manipulating and organising);
(b) Basic Skills (includes performing, measuring and reading);
(c) Tabulating and Data Processing (includes graphs); and
(d) Interpretation of Data.

That the written report is not a true representation of performance at practical work is reflected by the fairly low correlation of 0.25 between proficiency with which a practical task is performed and the quality of performance of the practical task (Buckley, 1970). There is therefore a need to assess not only what the student knows about the use of the laboratory for laboratory investigation but also what he actually does (viz. the different process skills) in the laboratory.

In recognition of certain deficiencies inherent in the use of the written report as the basis for judging a student's grounding in laboratory work, some staff members of the Institute of Education initiated a pilot study that was aimed at exploring the feasibility of an alternative to the conventional practical examinations based on the candidate's written report. Table 1 provides a comparison of the alternative treatment with that of the conventional practical examination which is based on the candidate's written report.

Description of the Study

The study attempted involves supervision of the learning of process skills that cannot be

TABLE 1 — COMPARISON OF LABORATORY ASSESSMENT COVERAGE

Process Skills Involved	Alternative Form for Assessing Practical Work	Conventional Practical Test for Assessing Practical Work
Experimental Set-up (includes manipulating and organising)	Teacher supervision emphasized, with student errors identified and corrected during normal practical sessions	Amount of supervision depends on individual teachers concerned; may or may not be judged from a practical examination report
Basic Skills (includes performing, measuring and reading)	Emphasized during on-going formative monitoring and also formally tested during basic skills test using video tape	Amount of coverage varies from teacher to teacher; mastery of skills left to chance; basic skills not tested during the practical examination
Tabulating and Data Processing (includes graphs)	Tabulating data emphasized during on-going formative monitoring. Data processing emphasized in interpretation skills test administered using simulated data	Both tabulating and data processing are being emphasized during the practical examination
Interpretation of data	Emphasized during interpretation skills test using simulated data	Emphasis placed on following instructions in the question paper during the practical examination

easily tested in a written test. The basic skills involved in setting-up, measuring and manipulating the apparatus, which are generally not easy to assess without being subjective, belong to this category. The process of on-going formative monitoring was used to ensure mastery of each skill. This way, immediate remedial work can be provided for those who fail to master a particular skill.

We will be the first to admit that this is a tedious process and the teacher-pupil ratio in a large class setting will make this a horrendous task. For the assessment of these skills, which are by and large neglected in the traditional practical examinations, we resorted to the video tape. The video tape not only is able to capture the close-up shots of specific skills, but also provides a cost-effective way to test large groups of students at one go.

An area that is also relatively neglected in traditional practical examinations up to the 'O' level examinations is that of data analysis and interpretation skills. In the traditional practical examinations, emphasis is placed on following instructions given in the question paper. Students are not called upon to demonstrate skills involved in the interpreting of data. We, however, deem the handling data as an important skill that needs to be acquired. As such the second part of our assessment of practical work is devoted to data analysis and interpretation skills. Again with cost-effective considerations in mind, these skills are assessed by us with a set of simulated data. This component requires transforming tabulated data into graphical form, accuracy of graph plotting, extracting information from the graph, and making sense of any equation given. It is our belief that a combination of these two parts provides a more accurate means of testing practical work. It is more accurate and meaningful in assessing a student's grounding in practical work. In fact as confirmation, the correlation between these two parts of the test is a low 0.13, which is not significant at the 0.05 level, because the skills tested in the two parts are different. There is therefore justification for separate assessment of these skills.

Of the two areas, we deemed it important to ensure consistency in outcomes between the formative monitoring stage and the actual administration of assessment. For this purpose an intact class of forty students was picked and a checklist of measuring skills was utilised for the formative monitoring stage of the study. The actual assessment involving measuring skills, administered one and a half months later, showed a respectable 85% consistency. The shortfall from perfection could be the result of differences in retention abilities.

For the purpose of comparison between the mode of assessment suggested by this study and the traditional practical examination, a traditional practical test was also arranged for the subjects concerned.

Results and Conclusions

The basic skills test together with the interpretation skills test results in a more comprehensive assessment instrument than the conventional practical test. Besides incorporating process skills into the assessment criteria for this alternative form of assessment, it is also more exacting in its demands as a test of mastery of practical work. On the other hand, the written report, the outcome of the traditional practical test, not only omits the assessment of process skills, but also cannot be used to reflect the quality of mastery of practical work. These differences are reflected in the non-significant correlation of 0.03 between the alternative practical test and the conventional practical test, at the 0.05 level.

Test Mode	N	$\bar{x}$	S.D.	Pearson's r
Conventional Practical Test	40	20.15	7.07	0.03
Alternative Practical Test	40	27.65	3.57	

One interesting fact to note is also the non-significant correlation at the 0.05 level, between:

* the basic skills test and the conventional practical test (r = 0.06);
* the interpretation skills test and the conventional practical test (r = 0.03).

This serves to confirm that the skills tested by traditional practical examinations do not include either basic skills or interpretation skills (see Table 1). In fact one major inadequacy of the conventional practical test is its obvious neglect of these skills. This means that the conventional practical test is not giving the necessary emphasis towards the process skills so clearly highlighted in today's science. Traditional practical examinations served their purpose of ensuring a candidate's grounding in practical work. It is, however, neither specific in its expectations, nor distinct in its promotion of process skills. In today's context it is therefore falling short of expectations of curricula changes taking place.

Whether therefore an alternative assessment which includes coverage of process skills, hitherto neglected in these practical examinations, should be attempted or not, will depend on the recognition of these skills as an important feature in practical work. Such process skills have become an established norm in the CDIS lower secondary science syllabus. What is unfortunate is the absence of follow through effort for the Secondary Three and Four levels in our schools.

REFERENCES

Buckley, J.G., ***An Investigation into the Assessment of Practical Abilities in 6th Form Chemistry Courses.*** Unpublished M. Sc. dissertation, The University of East Anglia, 1970.

Doran, R.L., Assessing the Outcomes of Science Laboratory Activities. ***Science Education,*** 1978, 62, pp 401-409.

Eglen, J.R. and Kempa, R.F., Assessing Manipulative Skills in Practical Chemistry. ***School Science Review,*** 1974, 56, pp 261-273.

Ganiel, V. and Hofstein, A., Objective and Continuous Assessment of Students' Performance in the Physics Laboratory. ***Science Education,*** 1982, 66(4), pp 581-591.

(Joint Matriculation Board) ***The Internal Assessment of Practical Skills in Chemistry.*** Universities of Manchester, Leeds, Liverpool, Sheffield and Birmingham. January 1979.

Lunetta, V.N., Hofstein, A. and Giddings, G., Evaluating Science Laboratory Skills. ***The Science Teacher,*** 1981, 48, pp 22-25.

Shulman, L.S. and Tamir, P., Research on Teaching in the Natural Sciences in ***Second Handbook of Research on Teaching.*** [R.M.W. Travers (Ed.)], New York: Rand McNally, 1973, pp 1098-1148.

Sim W.K. et al., ***Alternative Assessment Instruments: A Pilot Study in Chemistry and Mathematics Evaluation.*** University of Malaya, Science Cognate Group Project, 1975.

University of London, ***Notes and Guidance for the Optional Internal Assessment of Special Studies.*** University of London, 1977.