

The Measurement of the Educational Effectiveness of Laboratory Work in High School Chemistry in Israel

Thesis submitted for the degree "Doctor of Philosophy" By Abraham Hofstein

Submitted to the Scientific Council of the Weizmann Institute of Science

Rehovot, April 1975

Abstract

The research reported in this thesis was undertaken in order to examine aspects of the educational effectiveness of student-based laboratory work in chemistry and to explore the usefulness and acceptability of filmed demonstrations as an alternative to such laboratory work.

The work was undertaken against the background of a new curriculum developed for chemical education in Israeli High Schools. This curriculum, which in its basic structure adheres to the principle of laboratory-based inquiry, required for its implementation adequate laboratory facilities and related resources. In situations where, because of economic or administrative difficulties, such facilities cannot readily be provided, alternatives to student-based practical work are needed to make the implementation of the new curriculum possible. This realisation provides the main justification for the present study.

The main part of the work was concerned with a comparative investigation of the effectiveness of student-based practical work and of 'substitute' laboratory-oriented learning experiences provided by films. Eleven short films of the 'loop' type were prepared, each portraying an experimental situation which forms part of the new chemistry curriculum. The study involved a three-parallel-groups design characterized by the three treatment modes for laboratory activities:

- i. entire substitution of student experiments by films;
- ii. administration of student experiments only;
- iii. balanced programme involving student experiments and filmed demonstrations.

In all other respects, students belonging to the three treatment groups received identical instruction in chemistry.

The sample population consisted of 425 tenth grade students drawn from 15 teaching sets in seven secondary schools. Extensive pre-testing showed the treatment groups to have comparable cognitive and affective characteristics.

The experiment extended over a teaching period of between 12 and 16 weeks and was followed by extensive testing to measure students' theoretical and practical skills in chemistry. In addition, students' opinion of and attitudes to laboratory work and to filmed demonstrations were examined.

Comparison of the scores obtained for the two 'extreme' treatment groups ("film-group" and "experiments group") indicates that

- i. both groups develop equally well in their general understanding of chemistry;
- ii. both treatments are equally effective in developing in students knowledge of the principles underlying chemical experiments;
- iii. no difference results from the two treatments in students' ability to cope with laboratory-oriented problem-solving situations;
- iv. exposure to filmed demonstrations, as compared with direct laboratory work, enhances students' observational abilities with respect to the recognition and recording of colour changes;
- v. students exposed to individual laboratory work tend to develop greater manipulative skills than film-taught students, but recorded differences between the two groups are relatively small.

In the general sense, the two extreme treatment groups appeared similar in their attainment of most of the specific goals assessed. This suggests that filmed experiments are not inferior educationally to experimental work undertaken by students. However, students' attitudes to the filmed experiments as a substitute for their own practical work were less positive: it was generally felt by the students that higher achievement results from their own practical work than from vicarious experiences of experiments.

If students have some (subjective) reservations about the use of filmed demonstrations as a substitute for their own laboratory work, teachers were generally very positively disposed to their use. In particular, they saw film-based instruction as an effective way to solve administrative and economic problems associated with the provision of laboratory work in chemistry courses.

On the basis of the present research findings, it is suggested that filmed demonstrations could be used whenever administrative and economic difficulties prevent student-based practical work, and that such films be incorporated in the chemistry teaching programme for High Schools. An instructional approach utilising both filmed demonstrations and student-based laboratory work is strongly recommended.

The research gave rise to a number of peripheral findings related to the nature of chemical ability, to test design and assessment procedures. These are as follows- :

- i. Theoretical achievement in chemistry and laboratory skills represent two independent dimensions of students' chemical ability.
- ii. Within the practical domain, three distinct sub-abilities appear: problem-solving abilities, skills in the performance of routine laboratory exercises and observational skills. Observational attainment was found to be unrelated to all measures of intellectual abilities and is therefore classed as perceptual in nature.
- iii. Teacher assessment of their students' chemical abilities seems to focus attention entirely on their theoretical achievement. Performance in the laboratory is largely unassessed, despite the importance of this work within a

balanced chemistry curriculum. The methods used in this research would seem to provide the basis for the development of balanced and reliable assessment procedures for use by High School chemistry teachers.

Department of Science Teaching, Weizmann Institute of Science