AN INVESTIGATION
AT A WITWATERSRAND SCHOOL
INTO THE COMPARATIVE RESULT VALUE
OF THE DEMONSTRATION AND EXPERIMENTAL METHODS
OF TEACHING SCIENCE.

AN INVESTIGATION AT A WITWATERSRAND SCHOOL INTO THE COMPARATIVE RESULT VALUE OF THE DEMONSTRATION AND EXPERIMENTAL METHODS OF TEACHING SCIENCE.

A THESIS

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By

A. G. WILKE. B.Sc.

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CHAPTER I.

INTRODUCTION AND DEFINITION OF TERMS.

Whatever method of teaching is favoured by any Science teacher, the experimental facts on which his or her procedure is founded must be acquired in one of two places. These are the "experimental bench" or the "demonstration table".

In general any student of science has this division clearly in his mind. At one University, in the Physics Department, a printed Laboratory Note Book was in use for students in the first year. This book was divided into two portions, the one headed Experiments and the other Demonstrations. Experiments were carried out by the students following printed instructions but demonstrations were carried out by a lecturer before a group of students. These demonstrations were not part of the ordinary lectures, but were carried out in the laboratory.

In schools, no matter how much a teacher attempts to keep the child at individual experimentation, demonstration will be required to supplement general laboratory work, both to drive home facts and to round off schemes of work. The most enthusiastic believers in individual laboratory work are often forced to the demonstration table.

Certain experiments cannot be performed by pupils but must be demonstrated for one of the following reasons:-

(1) Aesthetic objections -- e.g. First dissections.

(2) Difficulty of technique -- e.g. Regnault's Experiment.

(3) Expense -- This operates more frequently than at first meets the eye and I shall revert to it subsequently.

I have heard it suggested and have often read that pupils must discover scientific laws for themselves. The believers in the Heuristic school of thought are said to try to place the pupil in the position of the original discoverer. I believe that such an idea is erroneous and have not met with any case of a boy rediscovering anything in the way of scientific laws. The teacher always supplies at the correct juncture a guide, either by judicious hint, careful questioning or even exasperated direct instruction. False and even fantastic inferences are the order of the day. It is perhaps, however, these very falsities and their correction that is the most valuable part of Science teaching. This correction leads to the appreciation of careful sifting of evidence, accurate judgment and to nice distinctions.

By training and desire I have always had a bias in favour of the pupil himself performing as much experimentation as possible. It seemed to me after some time, however, that portions of work demonstrated had apparently been as well absorbed by the pupils.

Colleagues, whose work I have been privileged to observe, have in some cases leaned in the one direction and sometimes in the other, their work yet being apparently equal. I have heard teachers, who favour as much laboratory work as possible, refer to the others as "lecturers" and "lazy". On the other hand, an inveterate demonstrator criticises pupil experimentation as "opportunity to loaf around the laboratory while pupils amuse themselves".

Demonstration lessons are said to be more effective on the grounds that manipulation is more exact; the guidance provided misses out no important point; the correct main principles receive their proper emphasis; no mistakes needing subsequent correction are made, and that "one big convincing and striking experiment is of more value than half a dozen little experiments".[1]

In the United States reading seems to indicate that much of their work is done by systems of laboratory training and many of their courses seem to be worked out on a basis of prepared books of laboratory instruction which are usually inductive and on Problem Solving Lines.

An example of such a workbook is that of Lake, Welton and Adell[2] in use in some schools in Cleveland, Ohio and elsewhere. It is divided into sixteen units. Unit 1 is headed "Do we live at the bottom of an ocean?" The unit is divided into some 9 problems. They are "What is air pressure?"

1. 1. John Brown. Teaching Science in schools. 1930. University of London Press.

2. C.H.Lake, L.E.Welton and J.C.Adell. A General Science Workbook. Silver, Burdett and Company, New York.

"Does air have weight?" and the like. Each problem is accompanied by definite experimental instructions with questions. Each unit is preceded by a bibliography for study and followed by a test.

A tentative syllabus for schools in New York State published under the auspices of the University of the State of New York is divided into such problem units.[1] It includes "suggestions for teaching procedure and pupil activities indicating many laboratory experiments for pupil performance or for demonstration by the teacher."

In Germany, apparently, not much was thought of experimental training for children and science teaching was inculcated by a system of lectures. No one would suggest that German Scientists have suffered thereby.

Dr. Muller, author of a thesis on the growth of Science teaching in Germany,[2] tells me that previous to 1937, German High Schools were divided into three types:-

(1) Ober - real - schule. No ancient languages were taught. More sciences with compulsory Physics and Chemistry experimental work after what we would regard as about Form III (Junior Certificate) standard.

1. Tentative Syllabus in General Biology. The University of the State of New York. The State Education Department. Albany, University of the State of New York Press.
2. H.Muller. Die geschichtlicke Entwicklung des naturwissenschaftlichen Weltbildes in den Schulfächern des preussischen Gymnasiums. - Doctor's Thesis 1934.- University of Koln.

(2) Real-gymnasium -- the most frequent type -- Latin, Science -- No compulsory individual experimental work. Voluntary experimental work in the last 2 years and before that, none.

(3) Gymnasium -- (Humanistisch) -- Latin, Greek, less Science but taught as in (2) above. After 1937 they were all combined into the Deutsche Oberschule which followed the same course up to about our Form III standard, then divided into language and Science Schools much like (1) and (3) above.

A floorplan of a renovated school in Berlin gives more floorspace to the workshop and teacher's laboratory, OR the lecture and preparation room than to the laboratory proper.

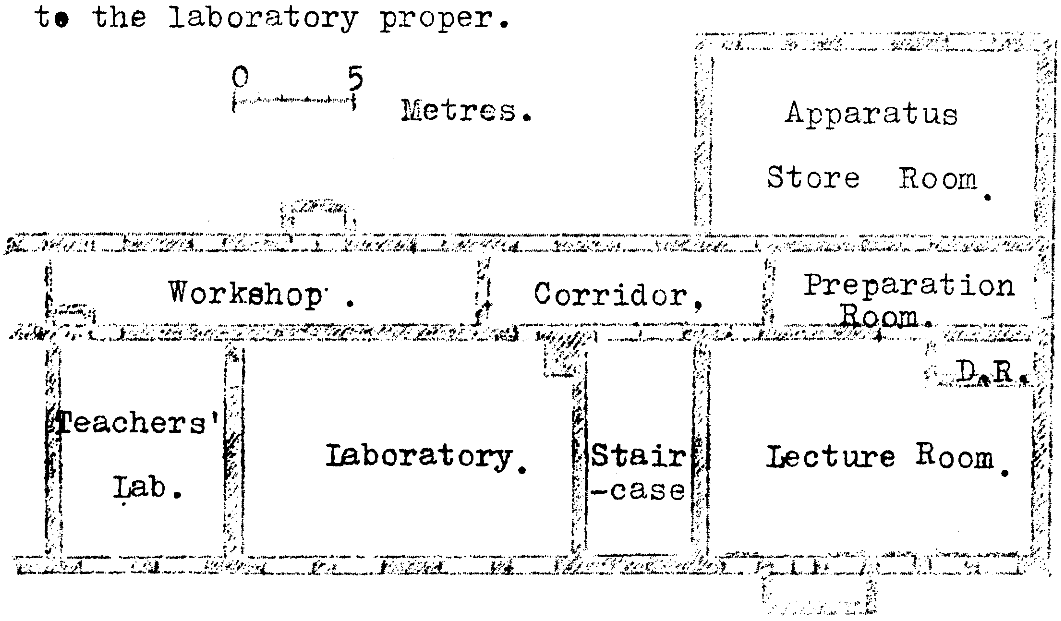


Diagram 1. Diagram of the rooms for instruction in Physics, (Dorotheenstädtisches Realgymnasium, Berlin, -- adapted from the floorplan)

Of the two systems Westaway[1] remarks "The Americans ascribe much of their National keenness to their system of laboratory training " and "The Germans ascribe much of their national thoroughness to their system of Science teaching by lectures."

1. F.W.Westaway. Science Teaching. Blackie and Son, London.

In England there has always been a use of the two methods, some teachers leaning towards one direction and some to the other. In the early days of Science teaching the demonstration method was to the fore but this was followed by a turn over to experimentation. At present there seems to be in use a judicious admixture of both, and this is in the main, the method used in this country, which has inherited a great deal of its educational system from English and Scottish teachers.

The following descriptions serve to indicate what is meant throughout this work by demonstration and experiment.

In my own work, I have had to prepare pupils for two Public examinations, The Transvaal Junior Certificate and the Transvaal Secondary School Certificate. The procedure has been as follows:-

A detailed draft of the scheme for each class was prepared. It was then gone through and all sections thought suitable for pupil experimentation were selected. In connection with this, availability of apparatus and expense were very frequently the determining factor. The remainder of work was done by teacher demonstration with an occasional classroom lesson to round off facts and to consolidate the knowledge of facts, hypotheses and laws learnt.

A teacher demonstration was not a lecture. The demonstration table was the Teacher's laboratory bench. At it, experiments were performed to illustrate facts. The pupils were asked at each stage what they observed, and after this for any inferences. In this manner they were led to the desired end by proper questioning, the questions being put with all the skill at the command of the teacher. It can be testified that a period so spent is most exhausting, and that a demonstrator is by no means lazy when the work has been carried out in this manner. It is true, however, that preparation of apparatus takes less time.

A class experiment was always carried out as follows, depending on the complexity of the experiment to be done. Pupils were given instructions before going to laboratory benches. These instructions were either verbal, written on blackboard or typewritten on single loose sheets. If possible the aim of an experiment and how that aim was to be achieved was first elicited from the pupils by questioning.

Inferences resulting from experimentation were elicited from the gathered class towards the end of the instructional period from the facts obtained from the class. The class then returned to their laboratory note books and entered the findings of the class and compared these with their own findings previously inscribed. As the smallest class ever handled consisted of 32 pupils, individual help over difficulties had to be infrequent and on that account experimental instructions were made as precise and as full as possible. The instructions were interpolated by suitable questions such as "What do you see?" "Describe" and so forth. The reason for full instructions was the result of early bitter experience of time wasted by pupils approaching the teacher's bench in droves soliciting aid. The period was one of work on the teacher's part and preparation of apparatus beforehand took considerable time. This becomes obvious when it can be stated that there was no laboratory assistant and that this lack is the rule rather than the exception.

As has been mentioned earlier, it did not seem on the surface of things, that either method produced a better result, although it is true that all the most difficult sections of the scheme were done by demonstration.

An attempt has therefore been made to determine which of the two produced the better result in the type of examination at present in use in the Transvaal.

CHAPTER II.

REVIEW OF PREVIOUS WORK ON SUBJECT.

As far as I am aware no previous work on this subject has been done in this or any European country. In Europe decisions have been made in the matter on grounds of common sense and experience which provide criteria by no means to be despised.

In the United States, that home of experimental education, several experiments have been carried out. They have been much upon the same lines in each case.

A section of work was given to two classes. One as taught by the teacher, the children doing no experimental work, the other did individual work, the teacher only giving such help as might be wanted by the individual pupils. The classes selected were of the same age and ability.

The conditions under which the subject was learnt were made as nearly equal as possible by the demonstrator following in his work as nearly as possible the instruction paper supplied to the pupils in the second class for their individual experimentation.

Kinsey[1] quotes a compiled table of results of experiments done in America as follows:-

1. A.C.Kinsey. Methods in Biology. University of Indiana Press.

Teacher Demonstration versus Laboratory Work.

Investigator.	Subject.	Immediate Test		Delayed Test.		Period
		Demons.	Lab.	Dem.	Lab.	
Anibel 1926	Chemistry	71.11	68.35	57.50	60.85	5 Months
Cooprider 1923	Biology	63.86	62.70	34.73	35.07	1 Month.
Cunningham 1920	Botany	60.3	55.2	31.0	34.6	3 Months.
Johnson 1928	Biology A B	51.9 61.19	48.9 61.72	42.1 60.11	41.4 55.48	1 Mnth. 2-4 Wks
Kiebler and Woody 1923	Physics A B	56.39 64.66	53.49 65.87	60.3 56.8	61.6 57.0	2 Wks. 2 Wks.
Wiley 1918	Chemistry	67.55	67.92	45.93	47.6	4 Wks.

This Author further remarks that " In comparison of grades note the degree of accuracy which has to be presumed in measurement in order to find significance in the differing result", but nevertheless goes on to say " Thousands of teachers have taken the experiments cited above to constitute full justification for the abandonment of the laboratory".

In connection with one of these American experiments Westaway [1] remarks " We must suspend judjment" and " It is quite unsafe to draw any general inference from such an experiment, the data are far too scanty, the factors involved too variable. The experiment might with advantage be repeated, other experiments with the same end in view devised and the results of different experiments compared".

He also mentions that to him the most interesting fact was that the next term "Lecture pupils not only attacked new problems better than

1. F.H.Westaway. Science Teaching. Blackie and Son, London.

the laboratory pupils but were actually more skilful in laboratory manipulation."

Equivalent groups were selected in different ways. R.E.Horton[1] set up nine groups varying in size from 26 to 128 pupils matched by standard deviations achieved in a previous preliminary examination. F.G.Anibel[2] used matched pairs selected by an intelligent test.

One exposition is that of Mayman[3] --- This is somewhat older but leads to much the same conclusions.

Briefly it is claimed that these experiments show that the demonstrations are more effective than laboratory work but that in delayed tests the details of experiments are remembered by laboratory workers for a longer time. Nevertheless it is claimed that the lecture pupils in the main still had clearer ideas about the experiments and their aims as a whole.

1. R.E.Horton. "Measurable outcomes of Individual Laboratory work in High School Chemistry." Teachers' College. Columbia University contributions to Education. No.303. New York, Bureau of Publications. Teachers' College, Columbia University. 1928. Also quoted by W.S.Munroe and Max D.Engelhart. The Scientific Study of Educational Problems. 1936. The Macmillan Co.
2. F.G.Anibel. Comparative effectiveness of the Lecture, Demonstration and Individual laboratory method. Journal of Educational Research. 13: 356. May, 1936.
3. J.E.Mayman. 1912. An Experimental Investigation of the Book method, lecture method and experimental method of teaching elementary Science in elementary schools. P.Blackstone Sons and Co., Philadelphia.

It is of interest to note the title of anarticle in an American Publication[1] - - "What, if anything, has really been proved as to the relative effectiveness of demonstration and laboratory methods in Science?" The underlining is mine.

This author reviews some 8 studies over and above 26 studies investigated by E.D.Curtis[2] The following are his chief complaints:-

"(1) Cases in which number of students used exceeded 20 (an arbitary number) - - - 2.
(2) Cases in which author reports or shows the use of objective tests of at least 10 questions. - - - - - - - - - - - - - 4
(3) Cases in which the research was published fully enough so that
(a) it could be intelligently criticized in all essential facts.
(b) it could be repeated with a high degree of likeness by other persons who might wish to verify the results or test their general applicability or definitely modify the demonstration or laboratory method or content for further study. - - - - - - - - - - - none."

The works he quotes are those of J.Y.Cooprider, Kiebler and Woody, H.S.Colton, F.G.Anibel, W.D.Carpenter, Wiley and Cunningham. After study of these quotations, I find that Cunningham favours experiment, Wiley, Cooprider, Kiebler and Woody favour demonstration, whereas Anibel is undecided and states "The delayed retention is so little different that one method may be considered as good as the other." and "Students were better able to do satisfactory

1. F.A.Riedel. "What, if anything, has really been proved as to the relative effectiveness of demonstration and laboratory methods in Science?" School Science and Mathematics. 27: 512 - 519 and 620 - 631.

2. E.D.Curtis. 1926. Investigations in the teaching of Science. 1926. Blackstons Sons and Co. Philadelphia.

laboratory work when this was preceded by an interval of demonstration work."

G.W.Hunter,[1] who mentions "I am still a believer in Herbart," set a questionnaire to students at the De Witt Clinton High School in which he endeavoured to ascertain the pupils reactions to various methods.

A. By experiments in laboratory work you did yourself.

B. By experiments performed by the teacher.

C. By field or museum trips.

D. By class discussions and assigned lessons.

E. By reference or outside reading.

Younger boys gave answers in favour of

A (28p.c.) B (20p.c.) C (17p.c.) D (3p.c.) E (4p.c.)

Whereas older boys of the age of 17

A (70p.c.) B (21p.c.)

Outside schools, presumably rural, gave

A (25p.c.) B (20p.c.) C(29p.c.) D (15p.c.) E (2p.c.)

Hunter comments that this shows "an astonishing change in method of attack. Older boys prefer the self active experiment method and give excellent reasons for their choice, while the younger children show a tendency to prefer the demonstrations."

1. G.W.Hunter. The problem of method in Elementary Biology. School Science and Mathematics. Vol. 27 : 1927.

CHAPTER III.

PART PLAYED BY EXPENSE IN DETERMINING RATIO OF DEMONSTRATION TO INDIVIDUAL EXPERIMENT.

Expense plays a greater role in the determination of the form of experimentation done inschools than at first meets the eye.

It is true that much material can be improvised, but some advocates of home made apparatus go a little too far. Boyle's Law is to be performed with the help of a bicycle pump and creditable figures have, I believe, been published for experiments involving the use of this piece of apparatus. Cawthorne[1] states he cannot prevent air leaking past the washer. I have had a class of pupils use such pumps and found that the escape of air nullified the experiments.

Teachers have been exhorted to make or have apparatus made. One order for two dozen mouth blow pipes placed by me was struck out by the official red ink and the following written above it "Make in the Manual Training Centre." I doubt that any boys could use the precision drill capable of making the small hole in the tip of a mouth blow pipe. With this our Handcrafts Instructor concurs.

1. H.H.Cawthorne. Science in Education. 1930. Oxford University Press.

I have before me a set of little books called "Handwork Science."[1] In them are extremely good suggestions for the making of apparatus for the carrying out of some 72 lessons. The course covers 2 years work and was carried out by the senior boys of the Old Whittington C.School, Chesterfield. I notice, however, that an equipment of tools is needed, there is a quantity of material required, bought apparatus creeps in here and there, and the syllabus is made to fit the scheme, and not the scheme to fit the syllabus.

I think that it may be stated that apparatus must be provided in order that good work may be done. The good teacher is surely worthy of good tools?

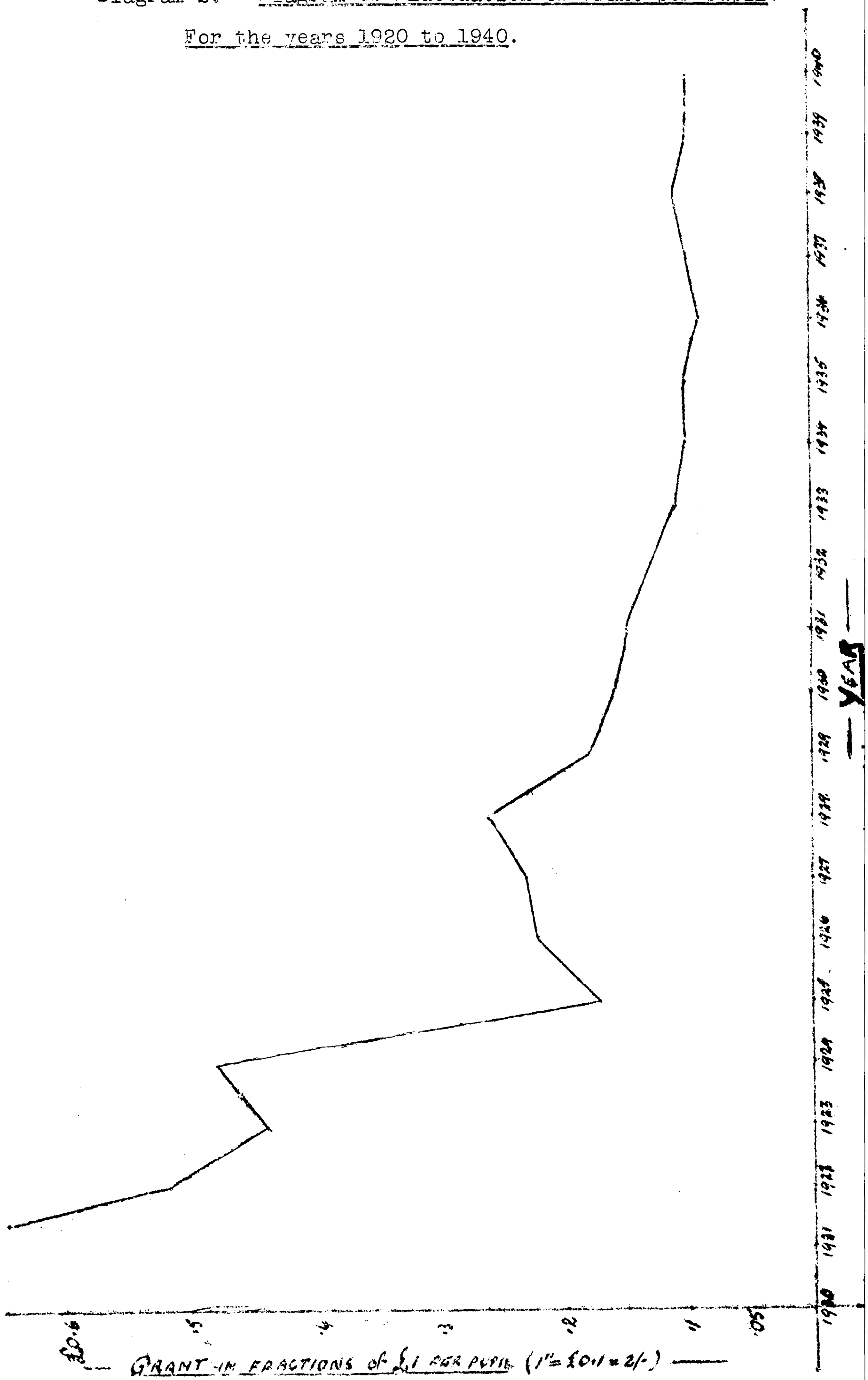
The money available to maintain laboratories in Transvaal schools fluctuates and has been governed to a great extent by the exigencies of Provincial Finance. I append[2] a series of figures giving grants available at one school, together with the average enrolment over a period of years.

These figures are diagrammatically illustrated in the graph which follows. If the years from 1920 to 1924, in which the laboratories (of which there are two) were being stocked are omitted, the grant for the running of the laboratories has steadily decreased. An increase appeared in 1925 to 1928, but the advent of a trade depression at about this time caused the amount to fall to £.06 per pupil in 1932. From that time onwards a steady amount of about 2/- per pupil was expended.

1. Claud Speakman. Handwork Science. Book 1. and Handwork Science. Book 11. Organiser of Handwork, Derbyshire Education Committee. McDougall's Educational Co.Ltd. London.
2. Appendix 1. Page 43

Diagram 2. Diagram of Fluctuation of Grant per Pupil.

For the years 1920 to 1940.



When comparing this figure with any overseas expenditure, it is well to remember that the price of apparatus here is usually higher.

From 1929 onwards no funds were allowed for purchase of additional permanent equipment. "In view of the financial position of the Province." Since that time such apparatus has been purchased from the annual grant. It may be added that from 1930 to 1935, the grant was accompanied by a warning "Although the amount referred to above is the maximum sum for which requisitions may be submitted, it is hoped you will find ways and means whereby it will be found feasible to run your laboratory without submitting requisitions to the full extent of your allocation."

Although the grant, as yet, still remains at the same level (1939, 1940), prices were, during those years, steadily on the upgrade owing to war conditions. This increase operates in exactly the same way as a reduction in grant. As an example of price increase the following may be given :-
Evaporating basins, test tubes, Mercury and Potassium hydroxide have almost trebled.
Flasks, microscope slides, Hydrochloric acid, beakers have doubled. In fact all glassware has doubled. The greatest increase I have noticed was that of a Kipp's Apparatus which has risen from about 15/- for the 500 cc size to over £2 for the 250cc size.

In England in 1925 it was found that in some large schools (30) amounts expended varied from 1/8 to £1-0-3 per pupil per annum.[1]

1. <u>Report of an inquiry into the conditions affecting the teaching of Science in Secondary Schools in England</u>. H.M.Stationery Office. 1925.

In America a report was published in 1930[1] giving estimated figures in several sciences. The report is "concerned with the smaller schools where experience shows that the facilities for teaching Science are often quite inadequate."

I have abstracted several summaries from this report[2] which seems to indicate that if it was acted upon the Science teacher who gloats over apparatus must surely find his heaven in Massachusetts.

It was a source of amusement to me to see that the figure for "Additional desirable apparatus for Chemistry" was $ 307.59. If the difference in cost of materials in U.S.A. and S.A. be taken into consideration, this figure for 20 pupils is in excess of the annual grant to our schools with rolls of 400 pupils.

The same report states however that "Experience shows that for upkeep from $ 200 to $ 400 should be allowed annually for a class of 20 in Chemistry." For Biology $ 100 to $ 300 is suggested. For Physics $ 200 to $400 and for General Science $ 100 to $ 200. The total sum of $ 800 as a starter for General Science is mentioned as "a very modest amount." I quote here a circular on apparatus of 23rd May, 1935, received in a school which hitherto had not taught General Science; having up to that time provided only for the usual mixture of Physics and Chemistry.

1. <u>Report on equipment, apparatus and materials for teaching Science in the Secondary Schools of Massachusetts</u>. Division of Elementary and Secondary Education and Normal Schools, State House, Boston, Massachusetts. Bulletin of Department of Education, The Commonwealth of Massachusetts. 1930. No.8. Whole No. 319.
2. Appendix II. Page 45.

This circular granted £20 " to meet the cost of initial equipment, new apparatus etc., required in connection with the teaching of Biology which is now included in the syllabus."

I do not think it unreasonable to state that present expenditure on apparatus in our schools precludes any attempt at laboratory training after the American fashion and further that it forces the teacher to a considerable amount of demonstration owing to lack of duplicate apparatus, when he himself might prefer the method of individual experimentation.

Universities commonly allow students to use apparatus in rotation, and as a result, multiply their apparatus in effect. This cannot be done in schools, as at no time can school boys or girls proceed to experiments out of their normal order.

It seems to me, therefore, that in any time of stress or during any financial difficulties the teacher of Science might well be forced to demonstrate more and more, and that some indication ought to be given as to where such increased demonstration will lead.

From a purely examination point of view, this becomes interesting in the light of the report of the Transvaal Secondary School Certificate Examiner[1] in Physical Science for 1939 which reads "It is this Examiner's policy to set a paper, dealing largely with such experimental work as may be expected to be performed by whole classes.

1. Transvaal Education Department - - Secondary School Certificate Examination. Reports by Examiners. Physical Science.1939

in their usual laborat ory course, and, presuming that the pupils will have returned to their teacher in their laboratory books experimental details of procedure, to expect these experimental details to be fully incorporated in the examination answers to these questions, The general tendency was to give theory and not practical details."

CHAPTER IV.

THE METHOD OF PROCEDURE.

A system of fortnightly tests was in use at the school and these were used. The tests used for this investigation were given at the usual intervals so as not to disturb the school routine.

It was decided to set up a series of 8 lessons in each of Forms I, II and IV. These three classes were chosen, as it was probable that I should be teaching more than one class in each the following year, and I wished, if possible, to use pairs of classes. Forms III and V were not used. It was thought that only one Form III and one Form V might be in my charge. Form III also did a portion of the syllabus which seemed to me unsuitable for the experiments.

During the year 1938 the General Science and Physical Syllabuses for all classes from I to V were carefully scrutinized, and some thirty lessons selected in each, which could be taught both by teacher demonstration and individual experimentation. Careful notes of lessons were made, together with tests and marking schedules for these tests. They were used and then carefully revised in the light of experience. The best were then selected for use in the coming year.

It was decided to use them in the third term of 1939 as it was thought that by this term classes would have completely settled down, have got used to the teacher's methods, and be able to follow his routine. At no time during the tests were the children aware that anything strange was afoot and the tests appeared to them to be those usually set throughout the year. To these they were thoroughly accustomed as the normal procedure was used all the time.

The classes used were Forms Ia, Ie, IIa, IId and IVb. Unfortunately no second Form IV was taught. Forms Ia and IV consisted of boys, IId and Ie of girls and IIa was mixed.

Furthermore, owing to the school organization, the pupils in Forms II and IV had been selected on the basis of the promotion examination in Forms I and III at the end of 1938. The pupils in IIa were considered the best and those in IId the worst, accordingto this arrangement. The Form I children were unknown to us on arrival and were therefore placed in classes at random.

To tabulate:-

Form Ia... Boys... Mixed ability.
" Ie... Girls.. Mixed ability.
" IIa... Mixed..Selected as best Form II.
" IId... Girls..Selected as worst Form II.
" IV... Boys ..Selected as poorer Form IV.

The time table[1] was so arranged in each class that 4 subjects of the 8 were by demonstration and 4 by experiment. Furthermore, where there were pairs of classes, the arrangement was reversed; in the second class those formerly done by experimental being now demonstrated and vice versa. It was felt

1. Appendix III. Page 48.

that in this way, any statement that tests or lessons were unequal might be met, provided that the outcome in both classes was the same.

To minimise learning or practice effect it was decided to rotate the tests. Thus the order in one of each of the pairs was arranged D E E D E D D E and of the other E D D E D E E D where the letters D and E represent demonstration and experiment repectively. This would tend to minimise also any effect due to age increase, which would probably be negligible in any case over so short a period.

A slightly different procedure was followed in Form IV, only however as far as tests were concerned. Here only three tests were given at monthly intervals. The first test was of experimental work, the third of demonstration work and the second was a mixed demonstration and experimental test, the two being separated during marking. All the work examined was in Chemistry in this class.

I have been, and am still, prejudiced in favour of experiment and this I thought might show in the marking. Apart therefore, from the rigid marking schedules, the scripts from pairs of classes were well mixed before marking. Furthermore the scripts were remarked a year later, during a school holiday, for checking purposes. Only then were they sorted and the raw scores recorded.[1]

The tests were arranged as nearly as possible to be of the usual examination type, the scoring to be similar. The tests and their schedules are appended.[2] A series of facts were taught in each lesson and each fact was scored

1. Appendix V. Raw Scores. Page 72.
2. " IV. Page 51.

as 2 points in the test answers.

Test and lessons were so chosen that adjacent pairs of tests obtained about the same maximum and the maximum total of the four demonstrations would approximate to the maximum total of the four experiments. Absolute equality in this respect was impossible to achieve as the nature of the tests would have been altered. The totals in Form II were 136 and 138 and in Form I 82 and 92. For practical purposes this produced equality in Form II but the difference in Forms I would have to be considered in computing results. Owing to the tests being of unequal length, the timing was also arranged to be 1 minute per fact in Form IV, 2 minutes per fact in Form II and 3 minutes per fact in Form I. Thus a test with a maximum of twenty facts and forty points in Form II would be allowed Forty minutes.

As it was my intention to compare the experimental work of each class with its own demonstration work, it was not thought necessary to secure equivalent groups. A method of comparing the pairs was however used and will be described in the next chapter where the results are analysed.

Class size was not considered as each class was of approximately 30 pupils. A small difference in numbers would have little effect. An American worker states that at the college level "within fairly wide limits, size of class does not appear to be an important educational factor."[1]

1. E.Hudelson. Class size at the College level. Minneapolis. University of Minnesota Press. 1938.

As previously mentioned, I have always believed that individual experimentation was the better method and this factor had to be borne in mind in estimating outcomes. "A requisite for highly effective instruction is that the teacher believes that he is employing a good procedure."[1] Great pains were taken to teach all lessons with the utmost care. More could not be done to meet this point.

The purpose of the experiment was to find the outcome in examinations of the usual type. It is contended however that the findings of the tests used would be valid for any form of test.

It is a common belief that essay type tests are not sufficiently objective, particularly as to scoring, to be reliable. The difference between essay and objective tests is said to be exaggerated in a paper[2] quoted by Monroe and Engelhart[1] who further state "measurement by means of an essay examination can be and usually is more direct." "hence it seems justifiable to conclude that in many cases an essay examination will be a superior instrument for measuring gains in achievement." and, "that the increase in reliability obtained by using and objective test is much less than is commonly supposed" provided that care is exercised in formulating questions. In support these authors quote.[3],[4] :-

1. W.E.Monroe and Max D.Engelhart. The scientific study of Educational problems. The Macmillan Co. 1936.
2. W.S.Monroe and L.B.Sanders. The present status of written examinations and suggestions for their improvement. University of Illinois Bulletin. No.17. University of Illinois. 1923.
3. E.S.Peters and H.B.Martz. A Study of the validity of various types of examinations. School and Society. 33: 336 - 338.March,193
4. W.S.Osborn. "Testing Thinking." Journal of Educational Research.27 : 401 - 11.Feb.,193

The matter of time used for each lesson or demonstration was difficult to decide upon. The fact that one method might take longer than the other was obvious, and it was felt that no lesson should be penalised by curtailment or an attempt to finish within a definite time limit. Every lesson therefore, regardless of method was complete. It may be stated here that experimental lessons took anything from 10 per cent to more than double the time used for demonstrations. One cause of this increase was that all apparatus was previously prepared for demonstration and removed after the demonstration; whereas anything up to 10 minutes at the commencement is used by the pupils to gather apparatus, and up to 15 minutes at the end to clean benches and apparatus and replace it after the work was completed. The laboratory was and is so organized that every article has its place and the pupils were well acquainted with these. The times quoted above may well be regarded as a minimum. In connection with this matter of time Riedel[1] quotes Kiebler and Woody as stating "When the demonstration method gives equal or superior results it is to be preferred as it saves about one half of the time usually devoted to performing the experiments."

1. F.A.Riedel. What, if anything has really been proved as to the relative effectiveness of demonstration and laboratory methods in Science? School Science and Mathematics. 27; 512, 620 - 631.

CHAPTER V.

THE RESULTS AND THEIR INTERPRETATION.

The scores obtained by each pupil are appended on page 72 under the following headings :-

(1) Experiments.

(2) Demonstrations.

(3) Totals.

(4) Amended totals.

Both experiments and demonstrations are four in number, except in Form IV, where there are only two of each. The totals give the total scores for each pupil for each of the two groups. Amended totals arise from the fact that in any series of tests conducted over a long period, pupils frequently absent themselves, either from lessons proper or from the tests. Whenever this has occurred no mark has been scored for the particular test and on that account the total has, for that pupil, suffered correspondingly. In these cases, therefore, I have computed a mark for the missing score on a directly proportional basis from a consideration of the marks scored in other tests of the same type. The new total obtained, when this mark is included, has been called the amended total. As will be seen, this has not occurred frequently. In cases where more than two tests have been missed the pupil has been entirely omitted.

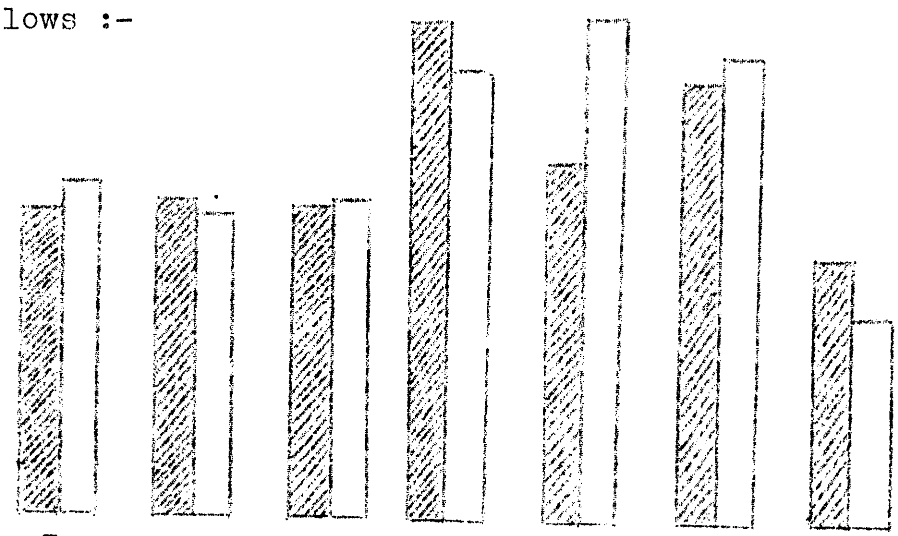
All arithmetic was most meticulously checked and rechecked throughout. Totals were checked by long and cross totting. The remainder of the arithmetic was checked by other individuals. I am reasonably certain that no error could arise from this source.

Monroe and Engelhart state that "when a measuring instrument consists of several subtests and a single composite score is desired ----- the scores may be added."[1] This is common practice.

From the total amended scores the arithmetic means were calculated with the following results :-

Form	la	le	la+le	IIa	IId	IIa+IId	IV.
Maxima	92	92	92	136-8	136-8	136-8	70-2
Experiments ...	64	66	65	104	75	92	58
Demonstrations.	69	63	66	93	105	98	44

In bar diagrams the above figures would appear as follows :-



Ia. Ie. Ia+ Ie. IIa. IId. IIa+ IId. IV.

Experiments. Demonstrations.

1. W.S.Monroe and Max.D.Engelhart. "<u>The Scientific Study of Educational Problems</u>." 1936. The Macmillan Co.

These figures <u>might</u> lead to the following conclusions :-

(1) Experimentation is better in Form IV.

(2) Demonstration is better in the lower Forms but very slightly so.

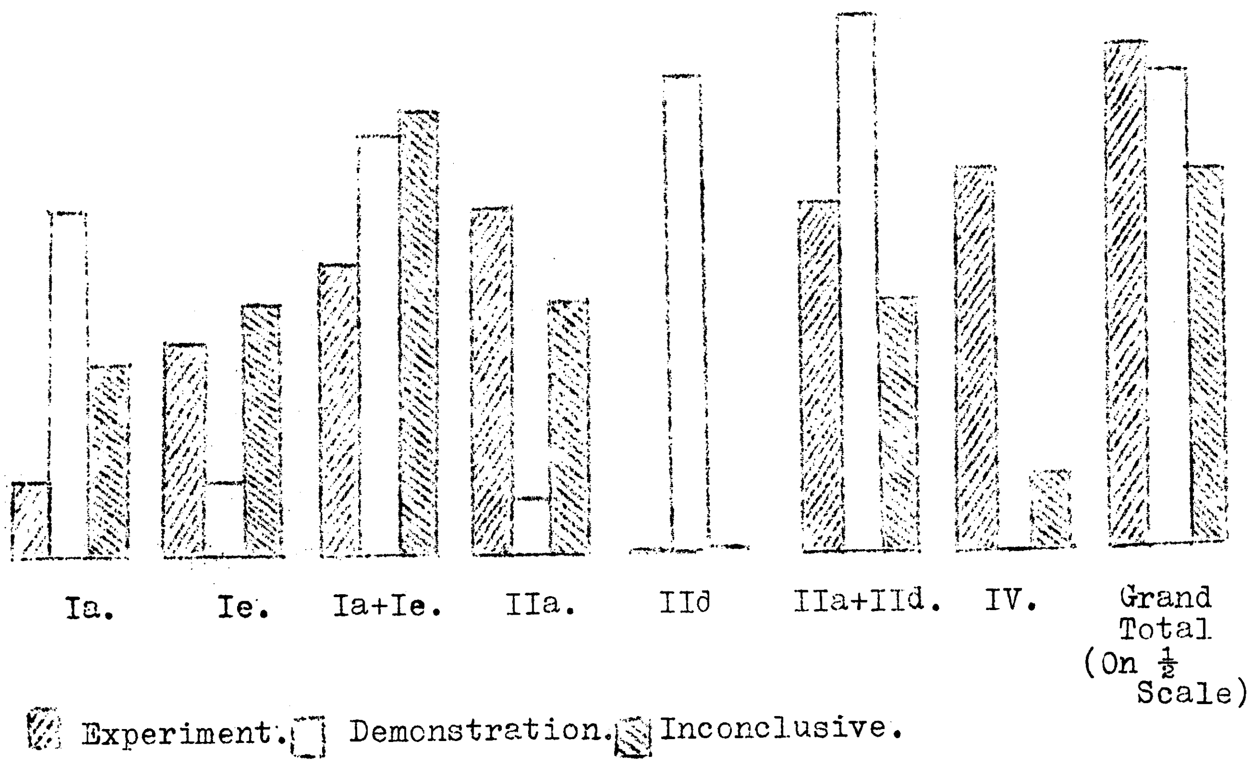
Arithmetic means are, however, notorious for the manner in which individual variations are covered up. On that account the individual scores for each pupil were scrutinised to see which method appeared for him the best. If the pupil's total for one method exceeded by over 6 points the total for the other method he was considered to benefit by that method. Otherwise the particular case was considered inconclusive. Besides considering the total, the tests were considered by pairs, and if the finding for the pupil was contradicted thereby the case was still considered inconclusive, despite the finding from the total. To facilitate comparison all scores were reduced to percentages and these are also appended. [1]

The findings from this procedure were as follows :-

Form	Ia	Ie	Ia +Ie	IIa	IId	IIa +IId	IV	Grand Total
Pupils benefitting from experiment.	4	11	15	18	-	18	20	53
Pupils benefitting from demonstrations.	18	4	22	3	25	28	-	50
Number inconclusive.	10	13	23	13	-	13	4	40
Number considered.	32	28	60	34	25	59	24	143

1. Page 78.

Bar diagrams for these figures are shown below:-



A very slight excess of pupils benefit by experimentation. In Form IV, however, practically the whole class do so benefit. In the lower classes, (Forms I and II) Demonstration appears best for the most pupils. In Form II it is well to note that practically the whole of those so benefitting come from Form IId. At first sight I thought this might be a matter of sex as Form IId was a Girls' Form. This was contradicted in Form Ie, also a Girls' Form, which showed just the reverse. Further examination allowed me to arrive at a suggested explanation, which will follow in due course.

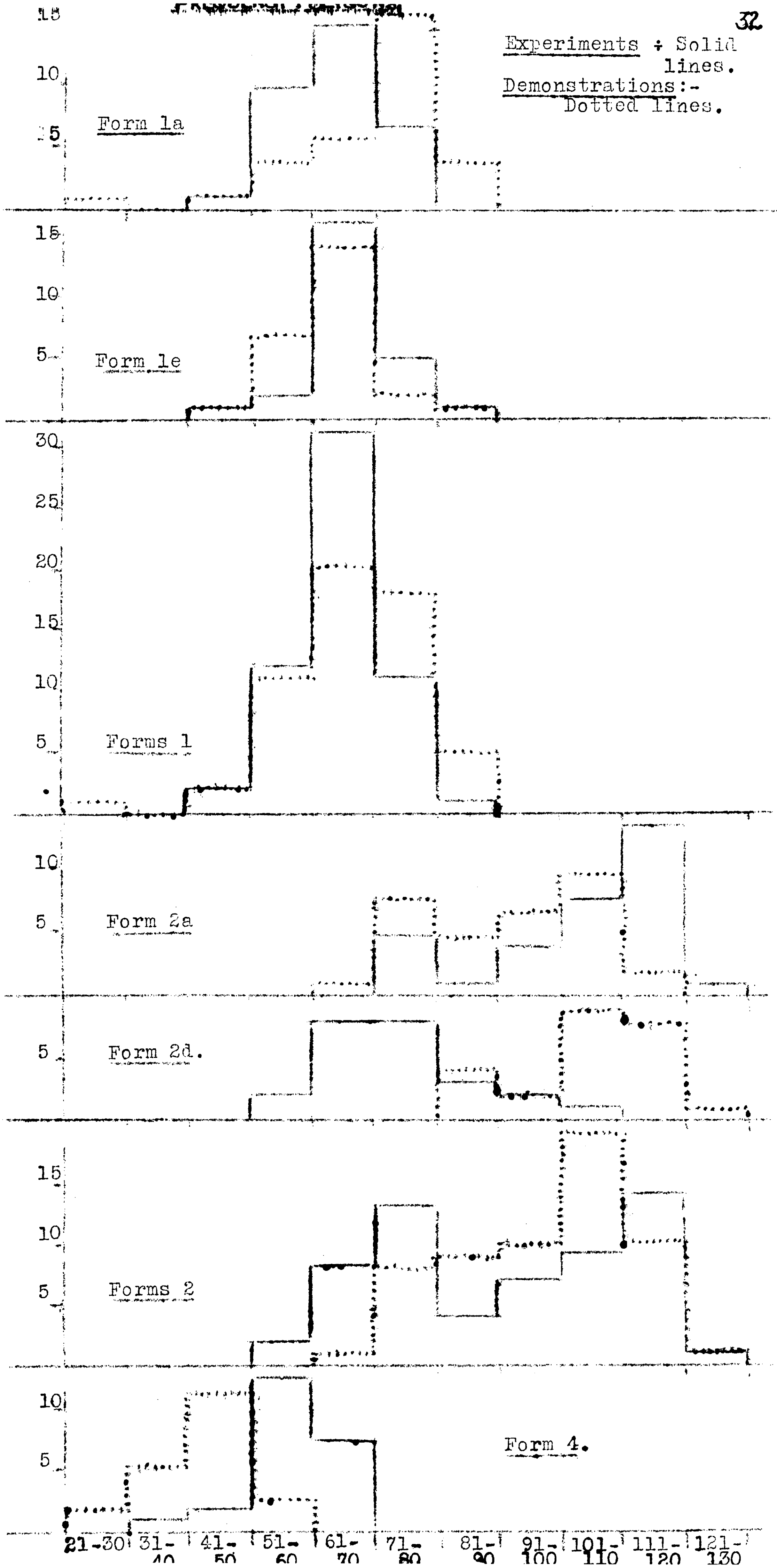
To examine the scores further, I threw them into a frequency distribution. The figures for this distribution are as follows. In each case the the crude mode is underlined and the interval is ten points.

Frequency Distributions.

Forms	Ia		Ie		Ia+Ie		IIa		IId		IIa+IId		IV	
Intervals	Ex.	Dem	Ex.	Dem	Ex.	Dem	Ex.	Dem	Ex.	Dem	Ex.	Dem	Ex.	Dem.
1- 10														
11- 20														
21- 30		1				1								2
31- 40		0				0							1	6
41- 50	1	1	1	1	2	2							2	13
51- 60	10	4	2	7	12	11			2		2		13	3
61- 70	15	6	16	14	31	20		1	8		8	1	8	
71- 80	6	16	5	2	11	18	5	8	8		13	8		
81- 90		4	1	1	1	5	1	5	3	4	4	9		
91- 100							4	7	2	2	7	10		
101- 110							8	10	1	9	9	19		
111- 120							14	2		8	14	10		
121- 130							1			1	1	1		
131- 140														
Total Pupils.	32	32	25	25	57	57	33	33	25	25	58	58	24	24

On page 32 these frequency distributions are illustrated in the form of histograms or frequency polygons. The experimental figures are superimposed on the demonstration figures for comparison.

A new peculiarity brought to light is the double peak or mode in Form IIa. The dependence of the Form IId Girls on demonstration is also clearly shown.


Experiments : Solid lines.
Demonstrations:- Dotted lines.
Form 1a
Form 1e
Forms 1
Form 2a
Form 2d.
Forms 2
Form 4.
5
10
15
20
25
30
21-30
31-40
41-50
51-60
61-70
71-80
81-90
91-100
101-110
111-120
121-130

Again the general conclusion to be drawn is that, in the lower forms, the demonstration is slightly more effective, whereas the experiment is better in Form IV.

The apparent anomaly of IId's total score in favour of demonstration might have been caused by

(a) Sex.

(b) Ability.

At first sight, sex might have been considered, especially as several of the girls in Form IIa (Nos. 25 to 34) showed better demonstration scores. Ie, however, was a girls' class and most of the Form I pupils, who scored in experiments, came from this class. Any influence of sex was, therefore, not considered as having any effect on the outcome.

In the matter of ability, it was thought that as IId was a known selected poor class, it would be well to examine the connection between ability and demonstration work.

The final positions obtained by pupils in the Promotion Examinations in December, 1939, were taken as a criterion of ability. These positions are included in the raw scores in the appendix from page 77 onwards.

All Forms I of the School were examined together. This was also done for the other forms. Positions obtained will thus be out of 151 for Forms I, 111 for Forms II and 46 for Form IV.

Each class was divided into three groups with reference to position and then each group was scrutinized to see whether it had benefitted more from demonstration or from individual experimentation.

The Forms I were divided into groups 1,2 and 3 with positions of 1 to 50, 51 to 100 and 101 to 151; the Forms II similarly with positions 1 to 37, 38 to 74 and 75 to 111. Form IV was divided into groups with positions 1 to 15, 16 to 30 and 31 to 45.

The figures obtained were as follows :-

Form	Ia				Ic				Ia + Ie.			
Group	1	2	3	Tot	1	2	3	Tot	1	2	3	Tot
Exp.	1	1	2	4	3	3	5	11	4	4	7	15
Dem.	6	7	5	18	0	1	3	4	6	8	8	22
Inc.	4	2	4	10	3	3	5	11	7	5	9	21
Total	11	10	11	32	6	7	13	26	17	17	24	58

Form	2a				2d				2a + 2d			
Group	1	2	3	Tot	1	2	3	Tot	1	2	3	Tot
Exp.	9	5	4	18	0	0	0	0	9	5	4	18
Dem.	1	0	2	3	7	7	10	24	8	7	12	27
Inc.	8	4	1	13	0	0	0	0	8	4	1	13
Total	18	9	7	34	7	7	10	24	25	16	17	58

Form	IV			
Group	1	2	3	Tot.
Exp.	3	5	11	19
Dem.	0	0	0	0
Inc.	1	2	1	4
Total	4	7	12	23

These figures when expressed as percentages of the Cross Totals (i.e. Method Groups) appear as follows :-

Form	Ia				Ie				Ia + Ie.			
Group	1	2	3	Tot	1	2	3	Tot	1	2	3	Tot
Exp.	25	25	50	100	27	27	45	100	27	27	47	100
Dem.	30	42	28	100	0	25	75	100	27	36	36	100
Inc.	40	20	40	100	27	27	45	100	33	24	43	100
Total	34	31	34	100	23	27	50	100	29	29	41	100

Form	2a				2d				2a + 2d.			
Group.	1	2	3	Tot	1	2	3	Tot	1	2	3	Tot
Exp.	50	28	22	100	0	0	0	0	50	28	22	100
Dem.	33	0	66	100	29	29	42	100	30	26	44	100
Inc.	61	31	7	100	0	0	0	0	61	31	7	100
Total	53	26	21	100	29	29	42	100	43	28	29	100

	Form IV			
Group	1	2	3	Tot.
Exp.	16	26	58	100
Dem.	0	0	0	0
Inc.	25	50	25	100
Total	17	30	52	100

The same figures expressed as percentages of the down totals (i.e. Ability Groups) appear as follows:-

Form	Ia				Ie				Ia + Ie			
Group	1	2	3	Tot	1	2	3	Tot	1	2	3	Tot
Exp.	9	10	18	13	50	43	38	42	24	24	29	26
Dem.	55	70	45	56	0	14	23	15	35	47	33	38
Inc.	36	20	36	31	50	43	38	42	41	29	38	36
Total	100	100	100	100	100	100	100	100	100	100	100	100

Form	IIa				IId				IIa +IId			
Group	1	2	3	Tot	1	2	3	Tot	1	2	3	Tot
Exp.	50	56	57	53	0	0	0	0	36	32	24	31
Dem.	6	0	29	9	100	100	100	100	32	44	71	47
Inc.	44	44	14	38	0	0	0	0	32	25	6	22
Total	100	100	100	100	100	100	100	100	100	100	100	100

	Form IV			
Group	1	2	3	Tot
Exp.	75	71	92	83
Dem.	0	0	0	0
Inc.	25	29	8	17
Total	100	100	100	100

In the above tables Exp. stand for experiments, Dem. for demonstration and Inc. for Inconclusive.

Considering the Form I totals it will be noticed that the pupils who benefit by experiment and demonstration are approximately evenly distributed. In the Form II totals, however, the pupils who benefit by demonstrations are definitely the inferior group. The poorer quality of Form IVb boys is shown, yet, nevertheless they benefit from experimental work.

It might be that inferior pupils in lower forms are so fully occupied by apparatus manipulation that they are unable to appreciate the outcome of their work.

I am also inclined to the view that inequality of test material may have operated in favour of the demonstration in Form IId. Since the tests were switched over in Form IIa, the presence of such an inequality would operate in favour of experiment. The totals of Forms IIa and IId would not show this, as any inequality would tend to cancel out. I therefore consider that in the interpretation of the results more weight should be given in each case to the form's totals rather than to the work of each individual half.

I set a small questionnaire to several classes of pupils in the school a year later. classes taught by teachers other than myself were also included.

Questionnaire.

(1) From which do you learn most

(a) Experiments done for you by your teacher?

(b) Experiments you do yourself?

(2) Which do you remember best

(c) The experiments you did at the laboratory bench ?

(d) The experiments done by your teacher when you gathered round his bench ?

Give reasons why in each case.

Answers :-

			Forms.							
Forms:-	IIc	IId	IIa	IIIa	IIIb	IIIc	IVa	Va	Vb	Totals
AC	3	1	2	2	2	1	3	1	5	20
AD	1	2	0	1	5	6	3	3	3	24
BC	28	23	30	28	9	25	11	12	11	177
BD	1	2	1	3	4	2	0	1	0	14

Preference for individual experimentation was obvious throughout.

I consider pupils who gave AC and BD as their answers probably gave the matter insufficient thought, and I therefore count them as having " spoilt their voting papers."

Considerable ingenuity was displayed at times in the reasons given particularly in the case of those who chose Demonstrations.

Demonstrations.

(1) " Teachers explain more, and more carefully."

(2) " Paymore attention to your work."

(3) " Explanation follows step by step."

(4) " No apparatus to bother about."

(5) " Easier to ask questions."

(6) " More accurately done."

(7) " Teachers tell you more."

(8) "Teacher forces you to think."

(9) "What teacher does is more correct, I make slips."

(10) "Teacher stimulates interest."

Experiments.

(1) "Remember exactly what you did yourself."

(2) "You yourself refer to work."

(3) "Teacher corrects your errors afterwards."

(4) "Set up yourself and you know what you are doing."

There were some naive answers "You don't have to work so hard," and "I like it because teacher makes more pops" (explosions?) and " No one tries to borrow your apparatus" and "It's more fun to do it yourself."

All in all I do not think this questionnaire counts for a great deal. It does however confirm the general trend of the remainder of the investigation.

Finally, subjective as such an opinion may be, I am convinced that demonstration is better for less bright pupils in the lower forms. This is the conclusion after three years observation and much thought.

There is sufficient individual variation to make a possible fruitful source of study in finding the type of pupil which benefits by either method. I am sorry that the future car-eers of individual pupils are not traceable here.

CHAPTER VI.

CONCLUSIONS.

Despite individual variations in scores I think, nevertheless, that the following conclusions may be safely drawn:-

(1) There is very little difference in the result value of the two methods, but once introduced the method of experiment is to be preferred.

(2). Demonstration produces slightly better results in the lower forms and Experiment slightly better results in the upper forms. There is a definite change over from one to the other as pupils advance in the school. This seems in accordance with common sense. More able pupils benefit equally in the lower forms but the less gifted are possibly so occupied with the actual manipulation of apparatus that they are prevented from observing the outcome of their work. Professor S.J.van der Lingen has pointed out that this may be due to the fact that pupils come "from an environment where memory is at a premium and are thus likely to benefit from demonstration" and "that, at first, time is occupied with learning to manipulate."

(3) Time is saved by demonstration.

(4) There is no measure of the actual advantages to be derived from the individual experiment in which there is no examination. The conclusions in this paper are for examination and theoretical tests.

(5) Probably it is best to use a judicious admixture of both methods commencing with more demonstration in the lower forms and working up to as much experiment as possible in Form V.

(6) There are probably as many impenderable variables as there are teachers. It therefore behoves each teacher to find out for himself which method suits him best.

I would like to suggest also, that although I am unacquainted with the Dalton system, there seems to me to be in that system a possibility of rotating apparatus to meet the difficulty of shortage.

Finally being a firm believer in the individual experiment, I should like to give a few reasons for that belief and also to utter a warning for the benefit of anyone who thinks "Laboratory work should be discarded."

Education, despite the efforts on the part of reactionaries, must be and is utilitarian.

The Greeks prepared their children for citizenship of a city state and their chief concern was to train fighting citizens to defend that state. Athletics, martial music and the like occupied a great portion of the curriculum.

The attempt at "apprehending the nature of God" in the middle ages had its outcome in Monasticism and Scholasticism.

We are now in a technical age and as an Editorial in Nature puts it the child must be brought up " for the furtherance of the Nation's effort and purpose" [1]

South Africa is a young country seeing now the first growth of its industries which it is hoped will blossom and bear fruit in the no distant future. Suffice it that I quote Cawthorne[2]- - - - - - "An educational machine which does not produce the technical experts required for the efficient running of a country, whether it be at peace or at war, is unsatisfactory." It seems an axiom that technicians cannot be educated without laboratory training in the widest sense.

Actual manipulation gives all children that chance at creative achievement which is so necessary for their development.

"Fabricating consists in shaping matter,[3] in making it supple and bending it, in converting it into an instrument in order to become master of it. It is this mastery that profits humanity, much more even than the material results of the invention itself. Though we derive an immediate advantage from the thing made, as an intelligent animal might do, and this advantage might be all that the inventor sought, it is a slight matter compared with the new

1. Editorial. Education as a National Asset. Nature. Vol.147: No. 3716.

2. H.H.Cawthorne. Science in Education. 1930. Oxford University Press.

3. Henri Bergson. Creative Evolution. Translator - A.Mitchell. 1920. Macmillan and Co.

ideas and the new feelings that the invention may give rise to in every direction, as if the essential part of the effect were to raise us above ourselves, and enlarge our horizon."

APPENDIX I.

MONEY GRANTED IN A TRANSVAAL SCHOOL FOR MAINTENANCE OF LABORATORIES (2) FROM 1921 to 1940.

APPENDIX I.

Money granted in a Transvaal School for maintenance of laboratories (2) from 1921 to 1940. Physics and Chemistry were taught from 1921-1940 and Physics, Chemistry and General Science from 1931-1940.

Year	Grant	Average enrolment taken at end of 1st Quarter.	Grant per pupil in £1.	
1921	£200	261	.77	.766
1922	£150	288	.52	.521
1923	£150	343	.44	.437
1924	£150	309	.48	.485
1925	£55	331	.17	.166
1926	£55	254	.22	.216
1927	£55	238	.23	.231
1928	£55	211	.26	.260
1929	£40	231	.18	.176
1930	£30	191	.16	.157
1931	£35	237	.15	.148
1932	£24	414	.06	.058
1933	£54	489	.11	.110
1934	£50	480	.10	.104
1935	£46 + £20*	457	.10	.101
1936	£45	506	.09	.089
1937	£52	493	.10	.105
1938	£52	458	.11	.113
1939	£48	448	.10	.107
1940	£45	455	.099	.099

* Initial equipment for General Science -- Biology.

APPENDIX II.

ABSTRACT OF SUGGESTED COST OF MATERIAL FOR SCHOOLS IN MASSACHUSETTS.

APPENDIX II.

Abstract of suggested cost of material for schools in Massachusetts from "Report on equipment, apparatus and materials for teaching Science in the Secondary Schools of Massachusetts".-- Division of Elementary and Secondary Education and Normal Schools, State House, Boston, Massachusetts. Bulletin of Department of Education.

The Commonwealth of Massachusetts, 1930.

No. 8. Whole No. 219.

Summary of approximate costs for General Science -- No apparatus included for individual laboratory experiments.

Physical Apparatus for Demonstrations ...	$482.50
Biological and Geological Supplies	$203.40
Chemicals and Reagents	$ 29.47
Chemical Apparatus	$ 48.10
Hardware and Kitchen Utensils	$ 30.20
Miscellaneous Supplies	$ 7.44
	$804.11

Summary and approximate costs for Biology -- 20 pupils

Individual apparatus (20 pupils)	$576.15
General apparatus	$185.02
Chemicals	$ 41.50
Models, Wall Charts, Mounted Specimens..	$133.50
Additional desirable apparatus and Materials	$441.35
	$1,377.52

Summary of approximate cost for Physics -- 20 pupils

Individual apparatus -- 20 pupils	$1,097.43
Demonstrator's apparatus(1)Minimum	$ 669.95
(2)Supplementary.	$ 396.15
(3)Additional....	$1,053.80
Tools for Physics Workshop	$ 79.48
Miscellaneous	$ 56.82
	$3,353.63

Summary of approximate costs for Chemistry --20 pupils.

Individual apparatus	$239.09
General apparatus	$329.45
Reserve Stock	$ 31.24
Chemicals and Reagents	$128.54
Additional desirable apparatus	$307.58
Useful Minerals	$ 12.7
	$1,048.61

APPENDIX III.

TIME TABLE

for

DEMONSTRATIONS AND EXPERIMENTS

in

FORMS Ia, Ie, IIa, IId and IVb.

— TIME TABLE — 1939.

FORM IV		COMMENCE	AUG 1	AUG 8	AUG 15	AUG 22	AUG 29	SEPT 5	SEPT 12	SEPT 19
		END	" 4	" 11	" 18	" 25	SEPT 1	" 8	" 15	" 22
		TYPE	BOTH	BOTH	BOTH	BOTH	BOTH	BOTH	BOTH	BOTH
FORMS II	II A	COMMENCE	AUG 7	AUG 14	AUG 21	AUG 28	SEPT 4	SEPT 11	SEPT 18	SEPT 25
		END	" 10	" 17	24	" 31	" 9	14	21	28
		TYPE	D	E	E	D	E	D	D	E
	II D	COMMENCE	AUG 3	AUG 10	AUG 17	AUG 24	AUG 31	SEPT 7	SEPT 14	SEPT 21
		END	" 8	" 15	" 22	" 29	SEPT 5	" 12	" 19	" 26
		TYPE	E	D	D	E	D	E	E	D
FORMS I	I A	COMMENCE	AUG 4	AUG 11	AUG 18	AUG 25	SEPT 1	SEPT 8	SEPT 15	SEPT 22
		END	" 9	" 16	" 23	30	" 6	" 13	" 20	27
		TYPE	E	D	D	E	D	E	E	D
	I E	COMMENCE	AUG 7	AUG 14	AUG 21	AUG 28	SEPT 4	SEPT 11	SEPT 18	SEPT 25
		END	" 9	" 16	" 23	30	" 6	" 13	20	27
		TYPE	D	E	E	D	E	D	D	E

APPENDIX IV.

TEST QUESTIONS
and
MARKING SCHEDULES.

APPENDIX IV.

Test Questions and Marking Schedules.

Form IV. Test 1.

(1) Describe in detail how you would prepare a jar of nitrogen from the atmosphere.

(2) Give the properties of nitrogen known to you.

(3) Describe in detail how you would prepare a few jars of Hydrogen.

(4) Give the properties of Hydrogen known to you.

(5) Explain briefly experiments to illustrate the density and whether it burns or supports combustion.

Schedule of Marking.

(1)	Sketch showing aspirator, heated turnings and collection over water.	4.
(2)	Air slowly forced over	2.
	Copper turnings	2.
	Strongly heated	2.
	Collect over water	2.
	$2Cu + O_2 = 2CuO$	2.
(2)	Colourless, odourless, tasteless gas	2.
	Inert under laboratory conditions	2.
	About as heavy as air	2.
	Slightly soluble	2.
(3)	Sketch with thistle funnel in acid and collection by upward displacement	4.

	Zinc and dilute Hydrochloric acid	4.
	$Zn + 2\ HCL = ZnCL_2 + H_2$	2.
	Upward displacement or over water	2.
(4)	Colourless, tasteless, odourless gas	2.
	Lightest gas known	2.
	Burns forming water	2.
	Reducing agent	2.
	Slightly soluble in water	2.
(5)	Put a burning taper into gas -- ignites	2.
	but does not support combustion	2.
	Counterpoise inverted beaker	2.
	Pour gas into it.	2.
	Total	52

Form IV. Test II.

(1) How would you illustrate the reducing action of carbon ?

(2) How would you determine accurately the proportion of oxygen in atmospheric air ?

Marking Schedule.

(1)	Drill hole in carbon block.	2.
	Mix carbon extracted with oxide (litharge) to be reduced	2.
	Add a little water to form paste and charge hole	2.
	Direct reducing flame on mixture	2.
	Using low bunsen flame	2.
	Beads of metal form	2.
	Oxide + Carbon = Carbon-di-oxide + metal	2.

$2PbO + C = CO_2 + 2Pb$	4.
Sketch	2.
Total	20

(2) Sketch of tube in tall jar with P on end of wire 2.

Melt Phosphor-us in test tube of hot water 2.

Place wire in Phosphor-us and allow to cool 2.

Length of tube closed at one end 2.

Measure length 2.

Insert wire with Phosphor-us and set up in tall jar (as in diagram) 2.

Leave some time while P uses up oxygen 2.

Level inside and outside 2.

Take measurements 2.

$$P.C.Nitrogen = \frac{\text{Length still left}}{\text{Whole length}}$$

For accuracy the temperature and pressure must be considered 2.

Total 20

Test 111. Form IV.

(1) What substances are compounded together in water?

(2) Describe in brief 3 experiments in support of your statement.

---

(1) Hydrogen and Oxygen 2.

(2) Action of Sodium on water in the cold

Sketch of sodium on water at bottom of 6in. tubing and hydrogen flame at top 2.

Sodium as large as pea placed on top water in tube 2.

Gas rising burns when lit - - Hydrogen 2.

Litmus added to water turns blue 2.

Therefore presence of alkali 2.

Therefore basic oxide 2.

Therefore oxygen from water 2.

$Na_2O + H_2O = 2NaOH$ 2.

OR Action of steam on heated iron turnings

Sketch showing steam generator, heated turnings and collection over water 4.

Steam over heated filings 2.

Gas passes over to jar 2.

Not steam as it would condense 2.

Hydrogen found when tested with taper 2.

Examination of filings shows oxide 2.

$2Fe + 3O_2 = 2Fe_2O3$ 2.

OR Electrolysis of water

Sketch of Hoffman voltameter and connected battery 4.

Anode to positive pole and Cathode to negative pole 2.

Electrolyte water plus few drops H_2SO_4. Aq. 2.

Onpassage of current electrolyte gives gas at anode and cathode 2.

Cathode gas twice volume of anode gas 2.

Anode gas on test oxygen 2.

Cathode gas on test hydrogen 2.

OR **Eudiometer Synthesis.**

Sketch with tube on pad	2.
in mercury connected with leyden jar	2.
Fill with two parts Hydrogen	2.
and one part oxygen	2.
spark explodes	2.
$2H_2 + O_2 = 2H_2O$	2.
Heat in jacket	2.
2 parts steam	2.

OR **Synthesis by burning Hydrogen in Air**

Sketch with calcium chloride tubes and	
dry hydrogen flame burning against	
water cooled retort	4.
Dried by $CaCl_2$	2.
Drops of moisture form	2.
Collect and fall on anhydrous copper	2
sulphate turning it blue	2.
Therefore moisture is water	2.
Hydrogen probably combines with	
oxygen in atmosphere	2.
Total	50

Form II. Test I.

(1) Sketch Ferguson's Pyrometer. Describe an experiment in which it is used, and state the conclusion drawn therfrom.

(2) Describe fully what occurs when water is heated in a dilatometer. Sketch the apparatus. What is proved ?

(3) How would you prove that a gas expands when heated and contracts when cooled ? Sketch.

Schedule for marking.

(1)	Sketch of weighted retort stand horizontal	2.
	end resting on roller	2.
	with pointer and scale	2.
	Heating causes pointer to move	
	(say colockwise)	2.
	therefore causes expansion	2.
	and cooling causes reverse	2.
	therefore contraction	2.
(2)	Dilatometer with mark	2.
	On heating first contracts	2.
	Owing to glass expanding	2.
	Expands and rises on heating	2.
	Falls and contracts on cooling	2.
(3)	Dilatometer with bent tube	2.
	Containing ink as telltale	2.
	Moves up on heating -- expansion	2.
	Contracts on cooling	2.
	Total.	32.

Form II. Test II.

(1) How would you show that only a portion of the atmosphere supports combustion? (say of a candle)

(2) How would you measure this portion used up?

Schedule for Marking.

(1)	Float candle on water in porcelain basin	2.
	Cover with bell jar	2.
	After burning some time candle goes out	2.
	Therefore remainder unsuitable for combustion	2.
	Water rises in bell jar	2,
	Therefore portion of air used up	2.
(2)	Sketch	2.
	Float Phosphorous in basin	2.
	Cover with bell jar and mark level of water	2.
	Ignite Phosphorous	2.
	After water has risen level inside and out	2.
	Marknew level of water	2.
	Using measuring jar measure 2 volumes	2.
	Portion used will be about one-fifth	2
	Total	28

Form II. Test 111.

(1) What results when mercuric oxide is heated?

(2) What is oxygen mixture?

(3) What part does manganese dioxide play in the mixture?

(4) How do you test for oxygen?

(5) Complete the following table:-

Substance	Flame	Oxide formed	With water turns litmus.
Sulphur			
Carbon			
Phosphor-us			
Sodium			
Magnesium			

Schedule for Marking.

(1) Mercuric oxide = Mercury plus oxygen 2+ 2.

(2) 1 part manganese dioxide 2.

5 parts potassium chlorate 2.

(3) A catylist and it causes reaction to take place at a lower temperature 4.

(4) Glowing splinter bursts into flame 2.

(5) Table and contents 30.

Substance	Flame	Oxide	Colour.
Sulphur	Mauve	Sulphur-di-oxide	Red
Carbon	Red glow	Carbon-di-oxide	Red
Phosphor-us	Yellow and white	Phosphor-us - pentoxide	Red
Sodium	Yellow	Sodium-oxide	Blue
Magnesium	Blinding white	Magnesium - oxide	Blue

Total 44

Form II. Test IV.

(1) Sketch a blowpipe flame indicating its parts.

(2) Carbon plus mercuric oxide = Carbon-di-oxide plus mercury.

Indicate (a) The oxidising agent.

(b) The reducing agent.

(c) The substance formed by oxidation.

(d) The substance formed by reduction.

(3) What way would you reduce litharge?

Schedule for Marking.

(1)	Sketch showing inner and outer cones with labels.	4.
(2)	(a) Mercuric oxide	2.
	(b) Carbon	2.
	(c) Carbon-di-oxide	2.
	(d) Mercury	2.
(3)	Grind hole in carbon block	2.
	Fill with paste of carbon and litharge	2.
	Direct reducing flame onto it	2.
	Lead oxide plus carbon = Carbon-di-oxide plus lead	8.
	Sketch	2.
	Total	28

Form II. Test V.

(1) How would you prepare nitrogen?

(2) Does it burn or support combustion -- how do you know?

Schedule for Marking.

(1)	Sketch showing aspirator, heated combustion tube and collection over water	6.
	Air	2.
	Copper turnings	2.
	Heat	2.
	Copper plus oxygen = copper oxide	4.
	Collect over water	2.
	Allow first gas to escape (oil fumes, air)	2.
(2)	Does not burn	2.
	Does not support combustion	2.
	Put ignited splinter in gas jar --	
	does not burn	2,
	gas puts it out	2
	Total	28

Form II. Test VI.

(1) How would you prepare a few jars of hydrogen?

(2) Give the properties of hydrogen.

(3) Describe the experiments you would do to support your statements in (2).

Schedule for Marking.

(1) Preparation.

Zinc plus Hydrochloric acid = Zinc chloride plus Hydrogen

	Equation in words	4.
	Substances used Zinc	2.
	Dilute acid	2.
	Sketch (2 marks for correct position of thistle funnel)	4.
	Collect over water	2.
(2)	Colourless, tasteless, odourless	2.
	Lightest gas known	2.
	Slightly soluble in water	2.
	Burns. Explodes when mixed with air forming water	2.
(3)	Present gas jar to flame — pops —	2.
	Counterpoise beaker upside down on balance	2.
	Pour hydrogen into it	2.
	Total	30

Form II. Test VII.

(1) How would you prepare a few jars of CO_2?

(2) Why would you not use sulphuric acid?

(3) Describe the properties of CO_2 and give supporting experiments for your statements.

Schedule for Marking.

(1)	Sketch Thistle funnel down in liquid	2.
	Downward displacement	2.
	Equation in words	6.
	Calcium carbonate plus hydrochloric acid = calcium chloride plus water plus carbon-di- oxide	
	Marble chips	2.
	Dilute Hydrochloric acid	2.
	Down displacement	2.
(2)	Crust of Calcium sulphate	2.
	insoluble	2.
(3)	Colourless, tasteless, odourless gas	4.
	Slightly soluble, forming acid	2.
	Test with litmus	2.
	Heavy gas	2.
	Counterpoise beaker	2.
	Pour in gas -- goes down	2.
	Turns lime water milky	2.
	clears again	2.
	Does not support combustion	2.
	Burning splinter or turps. out	2.
	Soluble bicarbonate	2.
	Insoluble carbonate	2.
	Total	46

Form II. Test VIII.

(1) How would you separate a mixture of sand and salt in such fashion as to recover both ?

(2) Sketch and label apparatus for :-

1. Decantation.
2. Filtration.
3. Evaporation.

Schedule for marking.

(1)	Place mixture in beaker and add water	2.
	Stir well	2.
	Warm	2.
	Decant into filter funnel	2.
	Wash residue	2.
	Residue -- Sand	2.
	Filtrate -- Salt solution	2.
	Transfer salt solution to evaporation dish	2.
	Evaporate to dryness, recovers salt	2.
	Pierce filter paper, wash sand into dish	2.
	Evaporate to dryness -- recovers sand	2.
(2)	Decantation -- sketch.	4.
	Filtration -- "	6.
	Evaporation -- "	2.
	Total.	36.

(**Form I.** **Test 1.**

(1) Having drawn a circle explain carefully how you would measure its circumference.

(2) How would you measure its diameter?

(3) A circle has a diameter of 10 ft. What is its circumference?

(4) Explain carefully how would you determine the ratio $\frac{\text{circumference}}{\text{diameter}}$ using the lid of a tin.

Schedule for Marking.

(1)	Set a pair of dividers to a suitable interval	2.
	Step off round circumference -- count and find product.	2.
	Set dividers to any small portion left over, measure and add.	2.
(2)	Draw a line through centre and measure	2.
(3)	$C = \Pi \times D = \frac{22}{7} \times 10$	2.
	$\frac{220}{7} = 31.1$ ft.	2.
(4)	Wrap paper round edge of lid	2.
	and prick through overlap	2.
	Open and mwasure	2.
	Measure diameter at its widest	2.
	Find ratio $\frac{C}{D}$	2.
	Total	22

Form I. Test 11.

(1) Describe carefully each step you would take in proving that the area of a circle can be calculated from the formula -

$$A = \pi r^2$$

(2) Find the area of a circle of radius $3\,{}^1/_2$ ins.

Schedule for Marking.

(1) Prove that $A = \pi r^2$

(1) Cut circumference into equal pieces	2.
(2) Make sectors and cut them out	2.
(3) Paste to form a rectangle	2.
(4) Breadth - r	2.
(5) Side $= \frac{1}{2}$ circumference	2.
(6) $^1/_2$ circumference $= {}^1/_2 \times 2\pi r = \pi r$	2.
(7) $A = L \times B = r \times \pi r^2$	2.
(2) Find area of circle radius $3\,{}^1/_2$ ins.	
$A = \pi r^2 = \frac{22}{7} \times \frac{7}{2} \times \frac{7}{2}$	2.
$= \frac{77}{2} = 38\,{}^1/_2$ sq. ins.	2.
Total	18.

Form I. Test III.

(1) How would you determine the ratio between centimetres and inches ?

(2) How many centimetres in an inch ?

(3) If 1 cm. = .3937 inches how long is a metre in inches.?

Schedule for marking.

(1)	Draw a line	2.
(2)	Measure in inches	2.
(3)	Measure in cms.	2.
(4)	Ratio	2.
(5)	Repeat several times	2.
(6)	Take average	2.
(2)	2.54 cms / inch.	2.
(3)	1 cm. = .3937 in.	
	1 m. = 39.37 in.	2.
	Total.	16

Form I. Test IV.

(1) Sketch a pipette.

(2) How many ccs. of water will a pipette marked 25 ml. contain ?

(3) If the water from this pipette is weighed and found to weigh 24.8 grams, what would its' volume be ?

(4) Describe how you would measure 25 ccs. of water using a pipette.

---

(1)	Sketch of pipette showing shape	2.
	and mark	2.
(2)	25 ccs.	2.
(3)	24.8 ccs.	2.
(4)	1. Clean pipette with water	2.
	2. Draw water into pipette	2.
	3. Holding thumb on top run out to mark	2.
	4. Blow out or closing top warm out last drop	2.
	Total	16

Form I. Test V.

(1) How would you find the volume of a single lead shot ?

(2) Calculate the volume of an average zinc slug from the following record :-

No. of slugs used 100

Initial burette reading ...... 19.8 mls.

Final reading .... 15.1 mls.

Schedule for marking.

(1)	Count 100 shot into a beaker	2.
	Clean and fill burette $^1/_2$ full water	2.
	Remove air bubbles	2.
	Take initial reading	2.
	Add shot carefully -- water rises	2.
	Tap to remove air bubbles	2.
	Take final reading	2.
	Divide difference by 100	2.
	Sketch	2.
	Sketch of meniscus	2.
(2)	Initial reading 19.8 mls.	
	Final reading 15.1 mls.	
	Difference 4.7 mls.	2.
	Volume of slug $= \frac{4.7}{100}$ mls.	2.
	$=$ .047 mls.	2.
	Total.	26

Form I. Test VI.

(1) Sketch a balance and name the parts.

(2) Name the weights found in a box of weights.

(3) Name the precautions you would observe in using a balance to weigh an object.

Schedule for marking.

(1)	Sketch balance				
	Adjusting screws				2.
	Beam and rest				2.
	Knife edge and stirrups				2.
	Pointer and scale				2.
	Pillar and plumbob				2.
	Pan and lever				2.
	(Single mark for one only)				
(2)	50	20	20	10	2.
	5	2	2	1	2.
	.5	.2	.2	.1	2.
	.05	.02	.02	.01	2.
(3)	1. Level				2.
	2. Object in the left hand pan				2.
	3. Never remove or add weights etc. with beam free				2.
	4. Handle weights with forceps				2.
	5. Count weights on pan and on putting back				2.
	6. Adjust beam if necessary				2.
				Total.	32

Form I. Test VII.

(1) Describe in detail how you would find the density of a glass stopper.

(2) What is the density of a block of stone weighing 35.5 grams and having a volume of 15 ccs. ?

Schedule for marking.

(1)	Weigh the stopper	2.
	Fill measuring cylinder $^1/_2$ full of water	2.
	Take initial reading	2.
	Ease stone into cylinder without splash	2.
	Take final reading	2.
	Difference in volume	2.
	Density = M/V	2.
	Sketch	2.
	Read to bottom of meniscus	2.
(2)	$D = \frac{M}{V} \quad \frac{35.5}{15}$	2.
	$= \frac{7.1}{3} =$ 2.4 grams / cc.	2.
	Total.	22.

Form I. Test VIII.

(1) Describe in detail how you would find the density of wood given to you in the form of a rectangular block 5 x 5 x 5 cms.

(2) What is the density of glass a block of which measuring 6.5 x 1.2 x .6 cms. weighs 23 grams ?

Schedule for marking.

(1)	Mark 3 lines on block mutually at Rt. Ls.	2.
	Measure length	2.
	breadth	2.
	height 6	2.
	Volume = L x B x H	2.
	Weigh	2.
	Density = M/V	2.
	Sketch of block against metre stick	2.
(2)		
	$D = \frac{M}{V}$	2.
	$= \frac{23}{6.5 \times 1.2 \times .6}$	2.
	= 4.9 grams / cc.	2.

Total. 22

APPENDIX V.

TEST SCORES

FOR

FORMS Ia, Ie, IIa, IId, and IV.

TEST SCORES for FORM Ia.

	Experiments				Demon-strations				Totals		Amended Totals	
									Exp.	Dem.	Exp.	Dem.
Test No....	1	4	6	7	2	3	5	8	-	-	-	-
Date.[illegible]...	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
Maxima ..	22	16	32	22	18	16	26	22	92	82	92	92
Pupil.												
1.B.R.	10	12	20	20	8	12	26	18	62	64	62	72
2.B.B.	-	10	20	20	-	6	8	6	50	20	66	29
3.B.E.	6	12	16	20	12	10	26	16	54	64	54	72
4.B.D.	10	10	26	14	12	12	22	10	60	56	60	63
5.B.B.	8	-	26	4	6	10	22	14	38	52	46	58
6.B.M.	14	12	28	8	8	8	20	16	62	52	62	58
7.B.G.	18	8	28	20	6	12	24	18	74	60	74	67
8.B.J.	12	8	22	18	6	12	20	10	60	48	60	54
9.C.R.	14	6	22	18	-	16	20	16	60	52	60	75
10.C.B.	20	10	32	18	8	16	22	18	80	64	80	72
11.C.L.	8	6	25	14	6	12	16	10	53	44	53	49
12.D.A.	18	8	22	20	14	12	24	18	68	68	68	76
13.E.C.	-	14	28	14	-	10	22	14	56	46	74	52
14.F.L.	16	14	-	20	14	12	26	20	50	72	77	81
15.G.P.	6	10	22	18	10	12	26	18	56	66	56	74
16.H.D.	12	10	27	20	10	14	18	18	69	60	69	67
17.J.S.	18	10	22	14	16	12	20	16	64	64	64	72
18.J.R.	14	8	26	20	12	16	22	20	68	70	68	79
19.K.D.	14	8	30	20	10	12	26	18	72	66	72	74
20.L.M.	4	8	30	20	10	12	26	16	62	64	62	72
21.L.F.	16	8	26	20	8	12	26	20	70	66	70	74
22.L.G.	12	12	31	20	18	12	26	16	75	72	75	81
23.L.K.	12	8	23	20	14	10	24	18	63	66	63	74
24.M.A.	-	-	26	10	8	-	26	12	36	46	61	64
25.M.A.	6	8	29	20	8	12	24	18	63	62	63	70
26.M.H.	-	10	32	4	-	12	26	16	46	54	60	77
27.M.B.	10	6	32	12	14	16	24	16	60	70	60	79
28.N.B.	14	8	30	4	12	16	26	18	56	72	56	81
29.N.J.	12	10	24	18	12	12	24	16	64	64	64	72
30.O.R.	12	12	24	16	10	14	26	18	64	68	64	76
31.S.R.	12	8	30	20	18	16	22	22	70	78	70	87
32.M.B.	6	10	15	20	6	10	24	16	51	56	51	63

TEST SCORES for FORM Ie.

	Experiments				Demonstrations				Totals		Totals Amended	
									Exp.	Dem.	Exp.	Dem.
Test No....	2	3	5	8	1	4	6	7	-	-	-	-
Date 1939..	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				
Maxima ...	18	16	26	22	22	16	32	22	82	92	92	92
Pupil.												
1.B.V.	10	10	22	18	8	12	-	20	60	40	67	61
2.C.W.	16	8	22	18	10	12	21	20	64	63	72	63
3.C.C.	10	-	20	18	2	12	23	16	48	53	67	53
4.C.P.	10	12	20	20	8	10	19	16	62	53	70	53
5.F.E.	8	14	16	18	6	10	14	18	56	48	63	48
6.F.Y.	10	8	24	18	16	8	26	18	60	68	67	68
7.G.S.	8	12	22	16	8	10	20	18	58	56	65	56
8.G.P.	8	10	22	10	-	8	21	16	50	45	56	59
9.G.O.	10	14	6	-	-	6	21	20	30	47	46	62
10.H.Z.	14	14	18	14	14	8	23	20	60	65	67	65
11.K.D.	18	12	22	20	-	4	26	20	72	50	81	66
12.L.E.	10	8	22	18	16	16	29	22	58	83	65	83
13.L.E.	10	12	20	16	12	12	17	18	58	59	65	59
16.L.R.	14	14	24	18	16	12	24	20	70	72	78	73
17.M.I.	10	10	22	18	16	10	20	18	60	64	67	64
18.R.Y.	12	10	24	20	12	10	-	20	66	42	74	64
19.S.A.	10	8	22	14	14	10	--	16	54	40	61	61
20.S.J.	6	12	20	20	8	8	19	20	58	55	65	55
21.V.A.	14	10	-	20	4	12	28	18	44	62	72	62
22.W.H.	12	10	20	18	14	8	26	18	60	66	67	66
23.W.E.	10	12	20	16	14	14	24	20	58	72	65	72
24.W.A.	4	10	16	16	14	10	26	20	46	70	52	70
25.V.A.	10	14	20	18	8	-	-	6	62	14	-	-
26.V.E.	-	-	22	-	14	8	30	16	22	68	77	68
27.S.I.	14	12	20	16	10	14	24	-	62	48	70	63
28.B.A.	6	14	20	14	12	14	12	20	54	58	61	58

TEST SCORES FOR FORM 11a.

	Experiments				Demon-strations				Totals		Amended Totals	
									Exp.	Dem.	Exp.	Dem.
Test No...	2	3	5	8	1	4	6	7	-	-	-	-
Date 1939.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-
Pupil.												
1. A.C.	18	42	20	[illegible]	10	20	23	34	80	87	110	87
2. A.L.	12	42	16	36	12	22	17	24	106	75	106	75
3. B.B.	22	40	-	32	-	22	-	26	96	48	120	88
4. B.S.	24	38	20	-	-	20	-	32	82	52	113	96
5. C.I.	18	-	20	-	30	20	20	32	38	102	94	102
6. F.S.	22	38	18	-	30	14	23	32	78	99	108	99
7. F.V.	14	38	-	32	22	22	14	22	84	80	106	80
8. F.H.	18	44	22	-	16	-	17	38	84	71	116	89
9. F.N.	18	42	20	22	24	-	21	18	102	63	102	79
10. J.E.	20	42	24	32	29	22	28	28	118	107	118	107
11. J.E.	20	42	20	34	30	24	24	26	116	104	116	104
12. M.H.	20	42	20	28	30	20	22	26	110	98	110	98
13. L.B.	19	40	20	34	28	24	24	32	113	108	113	108
14. M.H.	22	40	18	34	30	20	29	32	114	111	114	111
15. M.M.	18	42	22	32	28	20	26	36	114	110	114	110
16. R.V.	-	20	12	32	14	16	19	26	64	75	80	75
17. S.A.	-	42	16	-	-	-	26	26	58	52	111	93
18. S.H.	24	44	20	36	26	22	26	24	124	98	124	98
19. S.C.	21	42	20	-	-	20	26	-	83	46	112	108
20. S.J.	-	24	18	-	12	20	-	16	42	48	80	62
21. T.A.	20	44	20	32	30	20	26	34	116	110	116	110
22. W.E.	-	42	16	38	-	28	26	30	96	84	120	110
23. W.R.	18	42	18	26	28	20	25	32	104	105	104	105
24. W.A.	18	42	22	36	32	20	26	36	118	114	118	114
25. E.J.	18	38	16	32	-	10	17	30	104	57	104	75
26. H.C.	18	36	22	22	20	24	28	32	98	104	98	104
27. J.J.	20	-	20	24	28	12	20	28	64	88	94	88
28. L.E.	12	28	-	-	-	12	15	30	40	57	77	75
29. L.P.	18	30	18	-	-	20	[illegible]	20	66	40	91	73
30. M.M.	20	40	-	-	26	-	-	-	60	26	-	-
31. M.C.	20	42	22	34	14	22	18	28	118	82	118	82
32. M.M.	-	22	20	28	28	20	18	32	70	98	88	98
33. S.B.	18	14	18	24	28	16	21	28	74	93	74	93
34. S.J.	16	26	-	22	18	20	16	24	64	78	80	78
Maxima	28	44	28	38	32	28	30	46	138	136	138	136

TEST SCORES for FORM IId.

	Experiments				Demon-strations				Totals		Amended Totals	
									Exp.	Dem.	Exp.	Dem.
Test No...	1	4	6	7	2	3	5	8	-	-	-	-
Date.[illegible]..	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-
Maxima ...	32	28	30	46	28	44	28	38	136	138	136	138
Pupil.												
1.A.G.	18	6	22	16	26	38	24	36	62	124	62	124
2.B.J.	16	-	19	18	24	-	18	32	53	74	67	109
3.D.P.	16	22	15	20	21	32	20	28	73	101	73	101
4.F.M.	30	20	7	16	24	38	22	36	73	120	73	120
5.H.D.	16	22	14	24	20	36	22	30	76	108	76	108
6.H.G.	24	20	30	26	22	34	22	34	100	112	100	112
7.J.T.	20	16	24	30	24	36	22	26	90	108	90	108
8.K.A.	24	18	10	18	22	38	22	-	70	82	70	113
9.K.S.	18	18	14	12	24	36	20	34	62	114	62	114
10.L.D.	-	22	29	32	26	-	24	32	83	82	108	120
11.L.A.	26	-	16	8	12	36	22	32	50	102	63	102
12.L.D.	26	22	26	22	20	40	22	34	96	116	96	116
13. L.A.	18	-	10	12	20	40	20	24	40	104	63	104
14.M.H.	24	18	13	16	18	18	20	30	71	86	71	86
15.M.D.	-	14	-	16	20	24	22	28	30	94	55	94
16.R.J.	10	22	23	22	21	38	18	32	77	109	77	109
17 17.R.E.	12	16	19	22	24	42	18	30	69	114	69	114
18.S.L.	28	20	16	18	17	38	16	-	82	71	82	98
19.S.S.	-	-	20	22	-	-	12	30	42	42	75	88
20.V.E.	20	18	13	20	19	18	14	30	71	81	71	81
21.W.N.	26	14	10	14	22	34	22	26	64	104	64	104
22.W.J.	16	-	18	22	-	26	16	32	56	74	71	93
23.F.F.	12	16	16	16	-	28	12	26	44	66	56	83
24.G.G.	30	16	17	24	21	40	24	28	87	113	87	113
25.O.M.	28	24	19	26	18	40	16	34	97	108	97	108

TEST SCORES for FORM IV.

Test No. / Date 1939 / Maxima / Pupil	Exp. 1 8/8 52	Exp. 2 23/6 20	Dem. 2 20	Dem. 3 20/8 52	Exp. Totals 72	Dem. Totals 70	Exp. Amended Totals 72	Dem. Amended Totals 70	Yr M. *	P † 45
1.B.V.	44	16	16	24	60	40	60	40	17.11	335
2.C.E.	42	16	12	30	58	42	58	42	16.8	29
3.D.D.	44	16	16	10	60	26	60	26	16.10	36
4.D.L.	46	18	16	46	64	62	64	62	16.5	6
5.E.C.	48	12	14	36	60	50	60	50	18.3	34
6.G.E.	46	-	-	32	46	32	64	45	16.2	13
7.G.D.	42	14	16	30	56	46	56	46	16 9	4
8.H.J.	36	12	10	26	48	36	48	36	15.8	40
9.H.R.	48	16	16	24	64	40	64	40	17	33
10.H.C.	42	14	14	30	56	44	56	44	17.2	26
11.H.D.	42	16	16	34	58	50	58	50	16.7	-
12.J.L.	44	14	6	36	58	42	58	42	16.8	42
13.J.W.	40	18	14	28	58	42	58	42	16	39
14.K.E.	38	12	18	30	50	48	50	48	15.11	16
15.L.E.	42	12	8	28	54	36	54	36	19.1	28
16.L.H.	46	16	14	16	62	30	62	30	15.6	31
17.L.S.	46	16	14	30	62	44	62	44	17.2	44
18.N.E.	24	16	8	28	40	36	40	36	16.5.	38
19.R.D.	44	14	16	34	58	50	58	50	16.4	27
20.R.A.	44	16	16	38	60	54	60	54	15.3	24
21.T.B.	48	18	14	30	66	44	66	44	16.8	25
22 W.F.	40	14	12	32	54	44	54	44	17.9	41
23.W.P.	50	18	18	42	68	60	68	60	15.9	3
24.W.E.	48	14	14	20	62	34	62	34	16.1	38

* Age in years and months.

† Position in all Form IV s in Promotion Examination December 1939.

TEST SCORES FOR FORM I a EXPRESSED AS PERCENTAGES.

Pupil	Age	Pos. *	Experiment. 1	4	6	Demonstration. 7.	2	3	5	8
1B.R.	13. 4	47/151	45	75	63	91	44	75	100	82
2B.B.	12. 7	131	..	62	63	91	-	38	31	27
3B.E.	13.7	71	27	75	50	91	67	62	100	73
4B.D.	14.8	115	45	62	81	64	67	75	85	45
5B.B.	13.6	111	36	-	81	18	33	62	85	64
6B.M.	13.10	47	64	75	87	36	44	50	77	73
7B.G.	15.2	92	82	50	87	91	33	75	92	82
8B.J.	12	129	55	50	69	82	33	75	77	45
9C.R.	15.5	60	64	38	69	82	-	100	77	73
10C.B.	13.11	25	91	62	100	82	44	101	85	82
11C.R.	13.1	127	36	38	78	64	33	75	62	45
12D.A.	12.8	78	82	50	69	91	78	75	92	82
13E.C.	12.9	138	-	87	87	64	-	62	85	64
14F.L.	13.3	31	73	87	-	91	78	75	100	91
15G.P.	13.6	105	27	62	69	82	56	75	100	82
16H.D.	12.1	17	55	62	84	91	56	87	69	82
17J.S.	13.8	21	82	62	69	64	89	75	77	73
18J.R.	12.9	41	64	50	81	91	67	100	85	91
19K.D.	14.6	14	64	50	94	91	56	75	100	82
20L.M.	14.8	130	18	50	94	91	56	75	100	73
21L.F.	13.1	75	73	50	81	91	44.	75	100	91
22L.G.	13.5	85	55	75	97	91	100	75	100	73
23L.K.	13.8	90	55	50	72	91	78	62	92	82
24M.A.	15.5	142	-	-	81	45	44	-	100	55
25M.A.	14.6	98	27	50	91	91	44	75	92	82
26M.H.	14	37	-	62	100	18	-	75	100	73
27M.B.	13.10	95	45	38	100	55	78	100	92	73
28N.B.	14.8	126	64	50	94	18	67	100	100	82
29N.J.	13	81	55	62	75	82	67	75	92	73
30O.R.	12.3	113	55	75	75	73	56	87	100	82
31S.R.	12.7	33	55	50	94	91	100	100	85	100
32M.B.	12.6	31	27	62	47	91	33	62	92	73

* Position obtained in December Promotion Examinations 1939 Forms I, with a total of 151 pupils.

TEST SCORES FOR FORM 1e EXPRESSED AS PERCENTAGES.

Pupil	Age.	Pos. *	Experiments. 2	3	5	8	Demonstrations. 1	4	6	7
1. B.V.	13.7	33 151	56	62	85	82	36	75	-	91
2. C.W.	13.2	116	89	50	85	82	45	75	66	91
3. C.C.	12.8	91	56	-	77	82	9	75	72	73
4. C.P.	15.	68	56	75	77	91	36	62	60	73
5. F.E.	15.	145	44	87	61	82	27	62	44	82
6. F.Y.	12.7	5	56	50	92	82	73	50	82	82
7. G.S.	14.5	123	44	75	85	73	36	62	63	82
8. G.P.	12.10	143	44	62	85	45	-	50	66	73
9. G.O.	14.10	146	56	87	23	-	-	38	66	91
10. H.Z.	13.10	97	78	87	69	64	64	50	72	91
11. K.D.	13.6	18	100	75	85	91	-	25	82	91
12. L.E.	13.2	39	56	50	85	82	73	100	91	100
13. L.E.	13.4	106	56	75	77	73	55	75	53	82
16. L.R.	12.11	59	78	87	92	82	73	75	75	91
17. N.I.	13.2	149	56	62	85	82	73	62	63	82
18. R.Y.	13.6	21	67	62	92	91	55	62	-	91
19. S.A.	14.7	107	56	50	85	64	64	62	-	73
20. S.J.	13.9	45	33	75	77	91	36	50	60	91
21. V.A.	13.9	117	78	62	-	91	18	75	88	82
22. W.H.	13.5	125	67	62	77	82	64	50	82	82
23. W.E.	14.3	102	56	75	77	73	64	87	75	91
24, W.A.	13.5	100	22	62	61	73	64	62	82	91
25. V.A.	14.5	95	56	87	77	82	36	-	-	27
26. V.E.	14.9	70	-	-	85	-	64	50	94	73
27. S.I.	14.10	147	78	75	77	73	45	87	75	-
28. B.A.	13.8	133	33	87	77	64	55	87	38	91

*Position obtained in December promotion examinations in 1939 out of 151 pupils.

TEST SCORES FOR FORM IIa EXPRESSED AS PERCENTAGES.

Pupil.	Age.	Pos. *	Experiments. 2	3	5	8	Demonstrations. 1	4	6	7
1.A.C.	13.	4/111	64	95	71	-	31	71	77	74
2.A.L.	13.3	87	43	95	57	93	38	79	57	52
3.B.B.	14.11	45	79	91	-	84	-	79	-	57
4.B.S.	13.7	16	86	86	71	-	-	71	-	69
5.C.I.	14.	13	64	-	71	-	94	71	67	69
6.F.S.	14.6	18	19	86	64	-	94	50	77	69
7.F.V.	14.11	53	50	86	-	84	69	79	47	48
8.F.H.	14.11	37	64	100	79	-	50	-	57	83
9.F.N.	15.6	34	64	95	71	58	75	-	70	39
10.J.E.	15.4	41	71	95	86	84	91	79	93	61
11.J.E.	15.3	1	71	95	71	89	94	86	80	57
12.K.H.	14.11	37	71	95	71	74	94	71	73	57
13.L.B.	14.	7	68	91	71	89	88	86	80	69
14.M.H.	14.	26	79	91	64	89	94	71	97	69
15.M.M.	16.	16	64	95	79	84	88	71	87	78
16.R.V.	15.6	68	7	45	43	84	44	57	63	57
17.S.A.	14.4	36	-	95	57	-	-	-	87	57
18.S.H.	14.6.	2	86	100	71	95	81	79	87	52
19.S.C.	14	10	75	95	71	-	-	71	87	-
20.S.J.	15.9	86	-	55	64	-	38	71	-	35
21.T.A.	15.5	60	71	100	71	84	94	71	87	74
22.W.E.	15.5	54	-	95	57	100	-	100	87	65
23.W.B.	15.4	27	64	95	64	68	88	71	33	69
24.W.A.	13.5	3	64	95	79	95	100	71	87	78
25.B.J.	14.7	97	64	86	57	84	-	36	57	65
26.H.C.	15.1	41	64	82	79	58	63	86	93	69
27.J.J.	14.4	79	71	-	71	63	88	48	67	61
28.L.E.	15.5	11	43	64	-	-	-	48	50	65
29.L.P.	14.8	55	64	68	67	-	-	71	-	43
30.M.M.	14.7	-	71	91	-	-	81	-	-	-
31.M.C.	15.5	104	71	95	79	89	44	79	60	61
32.M.M.	14.	97	-	50	71	74	88	71	60	69
33.S.B.	14.7	81	64	32	64	63	88	57	70	61
34.S.J.	14.4	24	57	59	-	58	56	71	53	52

* Position obtained in December promotion examinations, 1939. 111 Pupils wrote the Form II Examination.

TEST SCORES FOR FORM II d EXPRESSED AS PERCENTAGES.

Pupil.	Age.	Pos. *	Experiments. 1	4	6	7	Demonstrations, 2	3	5	8
1.A.G.	14.7	$\frac{94}{111}$	56	21	73	35	93	86	86	95
2.B.J.	14.3	64	50	-	63	39	86	-	64	84
3.D.P.	14.8	82	50	79	50	43	75	73	71	74
4.F.M.	15.7	74	94	71	23	35	86	86	79	95
5.H.D.	14.8	91	50	79	47	52	71	82	79	79
6.H.D.	14.	6	75	71	100	56	79	77	79	90
7.J.T.	14.3	100	63	57	80	65	86	82	79	68
8.K.A.	14.3	87	75	64	33	39	79	86	79	-
9.K.S.	14.9	107	56	64	47	26	86	82	71	90
10.L.D.	14.1	-	-	79	97	70	93	-	86	84
11.L.A.	15.2	108	81	-	53	17	43	82	79	84
12.L.D.	14.4	15	81	79	87	48	71	91	79	90
13.L.A.	15.11	102	56	-	33	26	71	91	71	63
14.M.H.	14.2	62	75	64	43	35	69	41	71	79
15.M.D.	14.4	48	-	50	-	35	71	54	79	24
16.R.J.	15.7	99	31	79	77	48	75	86	64	84
17.R.E.	15	22	37	51	63	48	86	95	64	79
18.S.L.	15.5	9	87	71	53	39	61	86	57	-
19.S.S.	15.2	46	-	-	67	48	-	-	53	79
20.V.E.	14.11	30	62	64	43	43	68	41	50	79
21.W.N.	16.6	60	81	50	33	30	79	77	79	68
22.W.J.	14.8	30	50	-	60	48	-	59	57	84
23.F.F.	14.7	85	37	57	-	35	-	64	43	68
24.G.G.	15.9	66	94	57	57	52	75	91	86	74
25.O.M.	15.7	23	87	86	63	57	69	91	57	90

* Positions obtained in December promotion examinations of 1939. 111 pupils wrote the Form II examination.

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