SOME EFFECTS OF THE NEW S. C. E. CHEMISTRY SYLLABUSES UPON INDUSTRIAL TRAINEES IN SCOTLAND

"Some Effects of the New Chemistry Syllabuses upon Industrial Trainees in Scotland"

by

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Glossary of Terms Used.

O-grade Examination.

This is the ordinary grade examination in chemistry, set by the Scottish Certificate of Education (S.C.E.) Examination Board, and taken normally by pupils in the fourth year of their secondary course at school.

The written examination,[1] which is external, is controlled by the S.C.E. Examination Board, and is normally one of the pre-requisites of entry to the O-1 stage of the Ordinary National Certificate (O.N.C.) course in chemistry.

O-1 Chemistry.

This is the chemistry 1 course which is part of the O.N.C. Course in Science. This, the first stage of the course, extends over one session of study at a Further Education (F.E.) College.

The written examination [2] is internal to each College.

O-2 Chemistry.

This is the chemistry 2 course which is a further part of the O.N.C. Course in Science. The O-2 stage of the course extends over a second session of study at a F.E. College.

The written examination [3] is external, being controlled by the Scottish Association for National Certificates and Diplomas (S.A.N.C.A.D.).

S1, S2, S3 etc.

This indicates the year of study in secondary school. The O-grade examination is normally taken toward the end of S4.

In Scotland, the majority of pupils commence the S1 stage at 12 years of age.

H-grade Examination.

This is the higher grade examination in chemistry, set by the S.C.E. Examination Board, and taken normally by pupils in S5.

Abstract

During the early 1960's new syllabuses in chemistry were introduced into Scottish schools. In 1970, a research programme [4] began to evaluate these new syllabuses, by comparing the attitudes and performances of university students who had been taught from a traditional syllabus, with those who had been taught from the new. The work embodied in this research is a contribution to the widening front of this research.

The pupils concerned in this work are those who did not go to university and who left school with an O-grade pass in chemistry, having been taught from a new syllabus. After school, the pupils proceeded to a F.E. College and studied O-1 chemistry, and in some cases, subsequently O-2 chemistry also, prior to taking up full time employment. The pupils concerned studied at F.E. College during the years 1970-72.

This research has sought to compare the attitudes of pupils to their O-grade and O-1 chemistry courses, and to discover where the main difficulties of the pupils lay, both in their theoretical and practical work. The views of their lecturers concerning the successes and failures of the new O-grade syllabus, have also been obtained.

The performances of individual pupils in the O-grade, O-1 and O-2 examinations have been compared with a view to establishing the existence or otherwise of any worthwhile correlations.

Arising from the results of this research, some recommendations are made to interested bodies, and an outline for the scope of any future work is suggested.

CHAPTER 1.

Chapter 1.

The Problems and How They Were Tackled.

The introduction of the Scottish "alternative" syllabuses in chemistry [5] in 1962, and the first examination thereon in 1964, were two of the results of a resurgence of scientific thinking which had taken place over the previous few years in Scotland.

The emphasis of these syllabuses was to relate facts to fundamental principles and it required "a somewhat different method of treatment" [5] on the part of the teacher if they were to be put into effect successfully.

The S.C.E. Examination Board, [6] constituted in 1964, gave attention to the need for their examinations in chemistry, even at O-grade, to test more than the abilities of candidates to remember and to describe - the main abilities tested hitherto.

In all of this, there was less emphasis in school on traditional laboratory training, and more on encouraging an ability to think and to make use of known facts in both familiar and unfamiliar situations. Clearly, this change of emphasis might give rise to disparities between the courses to which industrial trainees were exposed in F.E. establishments, and the O-grade courses in this "new" chemistry from which they had been prepared. Could an attempt be made to discover the magnitude of any disparity? This was one of the problems. Thought and discussion gave rise to others.

What were the problem areas which pupils of this calibre were meeting in O-grade chemistry?

Could the subjective views of students on their courses be substantiated?

Were the F.E. Colleges happy about the standard of chemistry reached by students who had passed the O-grade examination?

Were the new O-grade courses a suitable preparation for O-1 and O-2 chemistry courses - in regard both to content and practical training?

Were performances in the O-grade examination any guide as to subsequent performance in O-1 and O-2 examinations?

Might the possibility of revising O.N.C. courses in chemistry be worthy of consideration, in order to bring them into line with current O-grade courses - in regard to content and objectives (cognitive and affective)?

These problems seemed particularly worthy of consideration since the number of students involved was rising rapidly. Table 1 shows the increase in the number of candidates presented for O-grade chemistry between 1965 and 1972.

Table 1.

1965	1966	1967	1968	1969	1970	1971	1972
11,406	11,853	12,474	13,405	14,446	15,353	17,171	19,169

Consequently there was an increase in the number of students wishing to enter Further Education.

It was known that a similar investigation was being made into pupil difficulties at O-grade,[4] but not with the type of pupils who left school after S4 in order to study O.N.C. courses at F.E. Colleges. These were industrial trainees, the majority of whom had not passed the O-grade examination with very high marks - a point which is borne out by the figures given in chapter 4 of this thesis. One wondered if those pupils had experienced problems similar to the others who had performed better in the O-grade examination, and who had proceeded to higher courses in chemistry.

When the investigations covered by this work commenced in 1970, the report of the Committee on Technician Courses and Examinations [7] had just been published. While this report was primarily concerned with the needs of engineering technicians, and has been criticised by such bodies as the Royal Institute of Chemistry,[8] and the Joint Committee for National Certificates and Diplomas in Chemistry and in Applied Chemistry,[9] some of the problems to which it referred, such as the selection and wastage of students, courses, and the general development of courses, seemed to indicate that good might come out of both objective and subjective investigations into the current state of affairs in Scotland regarding the effectiveness of courses in chemistry which industrial trainees have to undertake.

Teachers and lecturers may have had their "hunches" as to what the answers to some of the problems referred to earlier were - as had the writer - but evidence had to be found.

There seemed to be a need for a scientific approach to the investigation of these problems in chemical education. Too often solutions to such problems have been determined by opinion and prejudice - a view which has been expressed by the Chairman of the Scottish Council for Research in Education.[10]

In an attempt to ascertain what the position was, the research presented in this thesis was designed in three stages.

1. To obtain the views of the students, and to attempt to substantiate these views.

   The various methods and results are described in chapter 2.

2. To obtain the views of the Lecturers in the F.E. Colleges.

   These are dealt with in chapter 3.

3. To compare the performance of individual students in three examinations - O-grade, O-1 and, where possible, in O-2 chemistry.

   This work is covered in chapter 4.

Initial Procedure.

In May 1970, S.A.N.C.A.D. was visited, and the approval of this body was given to commence research into the problems outlined, over a period of at least two years.

In June 1970 a meeting of Principal Lecturers in chemistry at F.E.

Colleges in Scotland, held in the offices of S.A.N.C.A.D., was attended by the writer. The aims of the investigations were outlined to these gentlemen, who agreed willingly to cooperate.

It was proposed to deal with students in nine F.E. Colleges. From figures made available by S.A.N.C.A.D.,[11] these nine Colleges contained approximately 95% of all O-1 chemistry students in Scotland, and 97% of all O-2 chemistry students.

Prior to asking the Principals of these Colleges for their agreement to make contact with their Departments of Chemistry, each Director of Education concerned was written, seeking his cooperation and permission to commence work. In no case was the request refused.

During the period October - December 1970, each College was visited and personal contact made with the Head of the Chemistry Department, or his equivalent. A further outline of the investigations which were contemplated was given to these lecturers.

In all of the work undertaken, H.M.I. Dr. J. Stark has been kept informed.

CHAPTER 2.

Chapter 2.

The Views of the Students.

A. Reactions to O-grade course.

Questionnaires - see appendix 2, 1 - were completed by over 300 students who commenced O-1 chemistry courses, in nine F.E. Colleges, in August 1970. Only those questionnaires were processed where the student had indicated the possession of a pass in the S.C.E. O-grade examination in alternative chemistry.

In addition to trying to establish the subjective views of the students towards specific areas of their O-grade course, the questionnaire attempted to determine the following additional factors:-

(i) How many students had decided on their occupation at this stage.

(ii) Why chemistry was chosen as a subject to be studied in S3.

(iii) When any liking for science in general was established.

(iv) Whether there was any particular reason(s) for the interest of the students in the subject of chemistry.

A slightly modified questionnaire - see appendix 2, 2 - was completed by over 200 students who commenced the O-1 chemistry courses, in the same nine F.E. Colleges, in August 1971. These students also had passed the S.C.E. O-grade examination in alternative chemistry.

In this second questionnaire, an opportunity was given to the students to indicate if any of the O-grade work in the examination syllabus had not been covered in school, and also to indicate a reaction to the amount of practical work in their school course.

The results of these investigations follow.

Job intention.

20% of the 1970-71 students, and 16% of the 1971-72 students, indicated that they were uncertain as to which job they would have when they left college. The majority of the students were motivated to do well in their college course.

Reason for choosing chemistry in S3 at school.

		1970-71	1971-72
(a)	a definite liking for chemistry	35.8	35.2
(b)	no other subject could be taken in its place	4.0	4.4
(c)	good examination results in science in S1 and S2	23.1	25.4
(d)	wanted to prepare for a job which involved chemistry	32.2	31.3
(e)	teachers at school pressed you to take it	3.0	2.7
(f)	parents pressed you to take it	1.4	0.9
(g)	other reason(s)	0.5	0.1

Students were permitted to make more than one response, and the results are expressed as a % of the total response. The consistency of the results indicate that they are likely to be genuine.

Comment.

While it is encouraging to see that many students admitted to a definite liking for chemistry, and wished to prepare for a job which involved chemistry, examination results in S1 and S2 were clearly important factors influencing their choice. This would seem to indicate that the chemistry content of the Integrated Science Course [12] presently being taught during the first two years in the majority of Scottish schools, will be an important factor in the decision of present day pupils whether to study chemistry in S3 or not. To most pupils the chemistry content of this course is probably indistinguishable from the rest in Integrated science.

There seems to be little pressure, either at school or at home, to influence the choice of the pupils, and few admitted to taking chemistry as a last resort.

The first liking for science.

	1970-71(%)	1971-72(%)
(a) in primary school	11.7	13.5
(b) in early secondary school	73.2	75.1
(c) in late secondary school	15.1	11.4

Comment.

A high percentage of the students experienced a liking for science in general before the age of 13. This would seem to indicate that the attempts which are made to increase the number of students taking chemistry in the senior stages of secondary school, and beyond, must start while the pupils are in S1 and S2. The importance of the curricula in science during these early years becomes even clearer, and it is hoped that attempts can be made to assess the achievements of the syllabus contained in Curriculum PapersNumber 7,[12] to which reference has been made.

Factors affecting students' interest in chemistry.

	1970-71	1971-72
(a) seeing a lot about chemistry on T.V.	7.5	8.1
(b) books which you have read	11.0	10.6
(c) a good teacher at school	41.5	40.8
(d) an interesting course in chemistry at school	37.0	40.5
(e) father's job involved chemistry	3.0	-
(f) any other reason(s)	-	-

The final option was not taken up by many students. Once again more than one response was permitted and the results are expressed as a percentage of the total response. The agreement between the years is excellent.

Comment.

The two most important factors are "good teachers" and "an interesting school course".

The affect of TV programmes was not significant. Perhaps this factor could become more important if more pure science programmes were shown which depicted the type of job which chemists do in various industries. Books seemed to be of only slightly more importance than television viewing.

Specific areas of difficulty.

Despite the efforts of the syllabus planners, it was becoming clear to teachers, by 1970, that pupils were experiencing areas of difficulty within the alternative chemistry syllabus at O-grade. But what were the views of the pupils?

The 1970-71 O-1 chemistry students were asked to indicate certain areas of the syllabus as:-

"Easy to Grasp", i.e. understood with little effort the first time they were taught;

"Difficult to Grasp", i.e. understood only after considerable effort, or

"Never really Grasped", i.e. material which was not understood and would have be retaught.

The 1971-72 O-1 students were given also the opportunity to indicate areas of the syllabus which had not been covered at school.

The results are given in Tables 2 and 3 below, and in the graphs 1-4 which follow. To permit ready comparison between the graphs covering each of the two groups of students, the results for the 1971-72 students are drawn on tracing paper in Graphs 1(b) 2(b) and 3(b).

Table 2.

The 1970-71 students' reactions to some O-grade topics. The results are expressed as percentages.

Syllabus Reference[1]	TOPIC	Easy to Grasp	Difficult to Grasp	Never Really Grasped
G1.	Atomic particles and their arrangement in the atom.	83	15.5	1.5
G2.	The idea of isotopes.	67	31	2
H1.	The chemical combination of elements to form compounds.	83	17	1
H2.	The difference between covalent and electrovalent (ionic) bonding.	59	38	4
H3.	Using the ion detector to measure the conductivity of solutions, and understanding the results.	41	46	13
H4.	Writing chemical formulae.	76	21	3
H5.	Writing chemical equations.	55	40	5
H6.	Calculating the formula weight of a compound.	69	29	2
H7.	Calculations from equations.	40	51	10
I1.	The idea of a reactivity series of metals.	85	14	2
I2.	The ionisation of water. The meaning of $H_2O \rightarrow H^+(aq) + OH^-(aq)$.	62	36	4
I3.	Electron transfer in oxidation-reduction (Redox) reactions.	44	50	7
I4.	Corrosion of metals. The idea of sacrificial protection.	87	13	1
J1.	Acidic and basic oxides.	67	30	2
J2.	What is meant by the pH of a solution.	93	3	3
J3.	The various methods of preparing soluble salts.	50	45	7

J4.	Precipitation reactions for preparing insoluble salts.	42	45	12
J5.	Using an indicator to tell when an acid has neutralised an alkali.	94	6	-
J6.	Calculations to find the molarity of a solution.	32	52	16
K1.	Ion-electron half-equations. The meaning of equations like $SO_3^{2-} + H_2O \rightarrow SO_4^{2-} + 2H^+ + 2e$ and $3e + NO_3^- + 4H^+ \rightarrow NO + 2H_2O$	29	52	17
L1.	The "cracking" of liquid hydrocarbons.	52	37	11
L2.	The distillation of crude oil to give a number of fractions.	71	23	5
L3.	The making of addition polymers, e.g. perspex, polystyrene, P.V.C.	51	36	13
N1.	The breaking down (hydrolysis) of carbohydrates using saliva or hydrochloric acid.	47	42	9
N2.	The formation of esters.	27	52	22
N3.	The conversion of fats to soaps.	39	45	16
N4.	How soaps and detergents clean.	70	22	6
N5.	Why a scum sometimes forms when soap is used for washing.	67	26	7
N6.	The importance of nitrogen containing compounds.	66	29	6
O1.	Making condensation polymers, e.g. nylon, phenol-formaldehyde.	32	47	21

Table 3.

The 1971-72 students' reactions to some O-grade topics. The results are expressed as percentages.

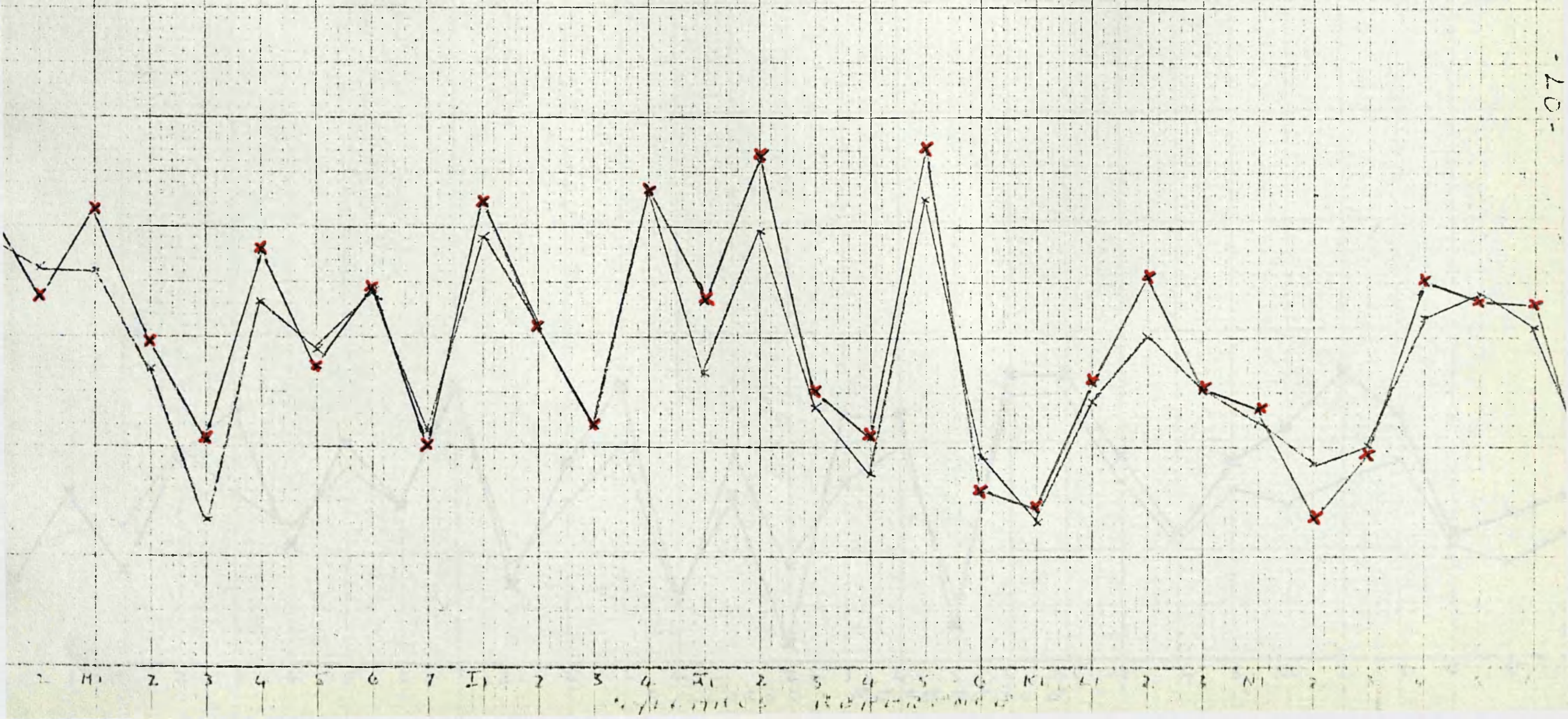
Syllabus[1] Reference	TOPIC	Easy to Grasp	Difficult to Grasp	Never Really Grasped	Did not Cover
G1.	Atomic particles and their arrangement in the atom.	79	18.5	2	0.5
G2.	The idea of isotopes.	73	23	2.5	1.5
H1.	The chemical combination of elements to form compounds.	72.5	24	2.5	1
H2.	The differences between covalent and electrovalent (ionic) bonding.	54.5	38	7	0.5
H3.	Using the ion detector to measure the conductivity of solutions, and understanding the results.	27	30	12	31
H4.	Writing chemical formulae.	67	24	3	6
H5.	Writing chemical equations.	58	35	7	-
H6.	Calculating the formula weight of a compound.	68	28	3	1
H7.	Calculations from equations.	43.5	49	6	1.5
I1.	The idea of a reactivity series of metals.	78	18	3	1
I2.	The ionisation of water. The meaning of $H_2O \rightarrow H^+(aq) + OH^-(aq)$.	62	29	9	-
I3.	Electron transfer in oxidation-reduction (Redox) reactions.	44	39.5	13.5	3
I4.	Corrosion of metals. The idea of sacrificial protection.	86.5	10	3	0.5
J1.	Acidic and basic oxides.	53.5	38	7.5	1
J2.	What is meant by the pH of a solution.	79.5	17	2.5	1
J3.	The various methods of preparing soluble salts.	47	32	9	12

J4.	Precipitation reactions for preparing insoluble salts.	35	39	9	17
J5.	Using an indicator to tell when an acid has neutralised an alkali.	85	11	2	2
J6.	Calculations to find the molarity of a solution.	38	48	9	5
K1.	Ion-electron half-equations. The meaning of equations like $SO_3^{2-} + H_2O \rightarrow SO_4^{2-} + 2H^+ + 2e$ and $3e + NO_3^- + 4H^+ \rightarrow NO + 2H_2O$	26	48.5	20	5.5
L1.	The "cracking" of liquid hydrocarbons.	48	32.5	11	8.5
L2.	The distillation of crude oil to give a number of fractions.	60	21	8	11
L3.	The making of addition polymers, e.g. perspex, polystyrene, P.V.C.	50	31	9	10
N1.	The breaking down (hydrolysis) of carbohydrates using saliva or hydrochloric acid.	44	28	13	15
N2.	The formation of esters.	37	32.5	17.5	13
N3.	The conversion of fats to soaps.	40	36	13	11
N4.	How soaps and detergents clean.	63.5	21	8.5	7
N5.	Why a scum sometimes forms when soap is used for washing.	67.5	17.5	5.5	8.5
N6.	The importance of nitrogen containing compounds.	61.5	22.5	7.5	7.5
O1.	Making condensation polymers, e.g. nylon, phenol-formaldehyde.	36.5	31.5	15	17

GRAPHS 1(a) and (b).

(a) "Easy to Grasp" Topics - 1970-71 Students. ×

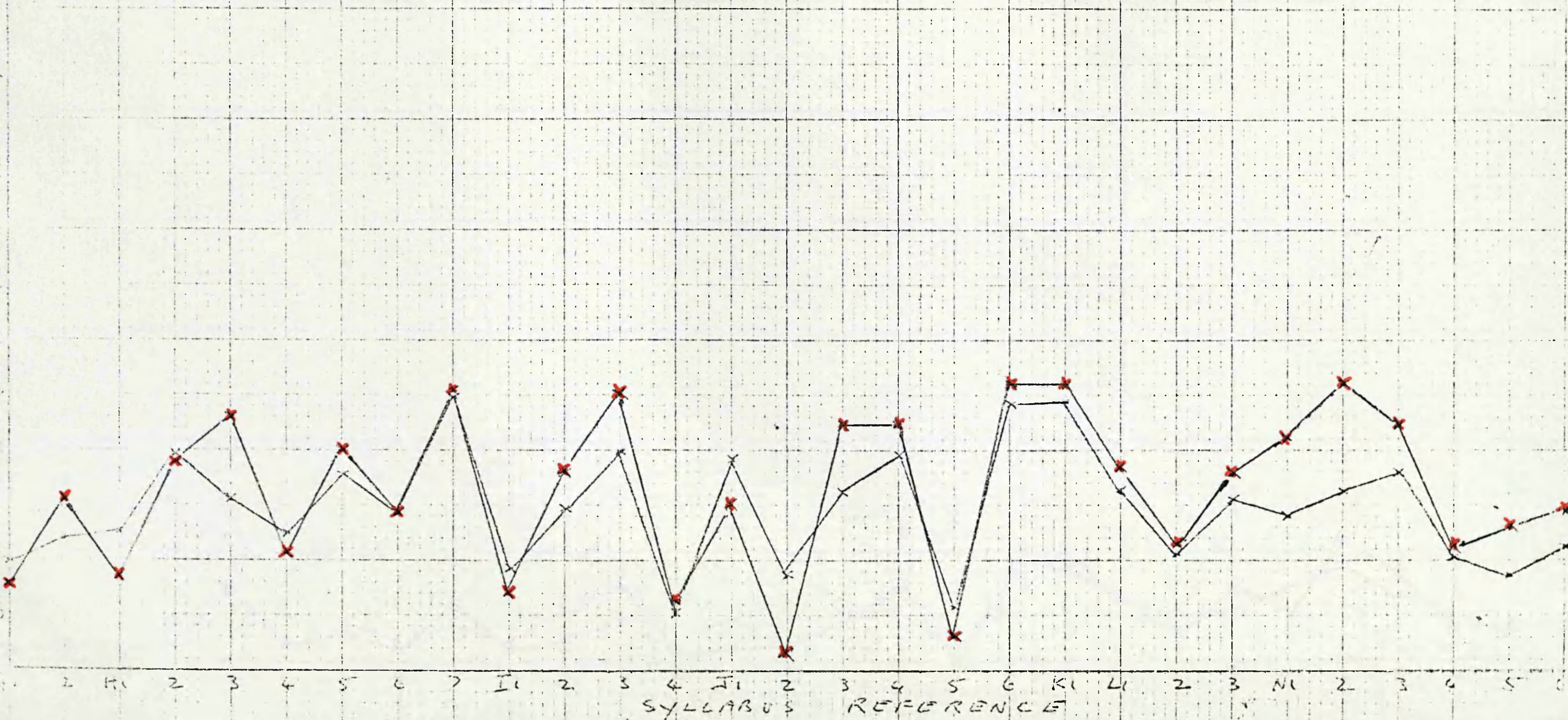
(b) "Easy to Grasp" Topics - 1971-72 Students.



GRAPHS 2(a) and (b).

(a) "Difficult to Grasp" Topics - 1970-71 Students. ×

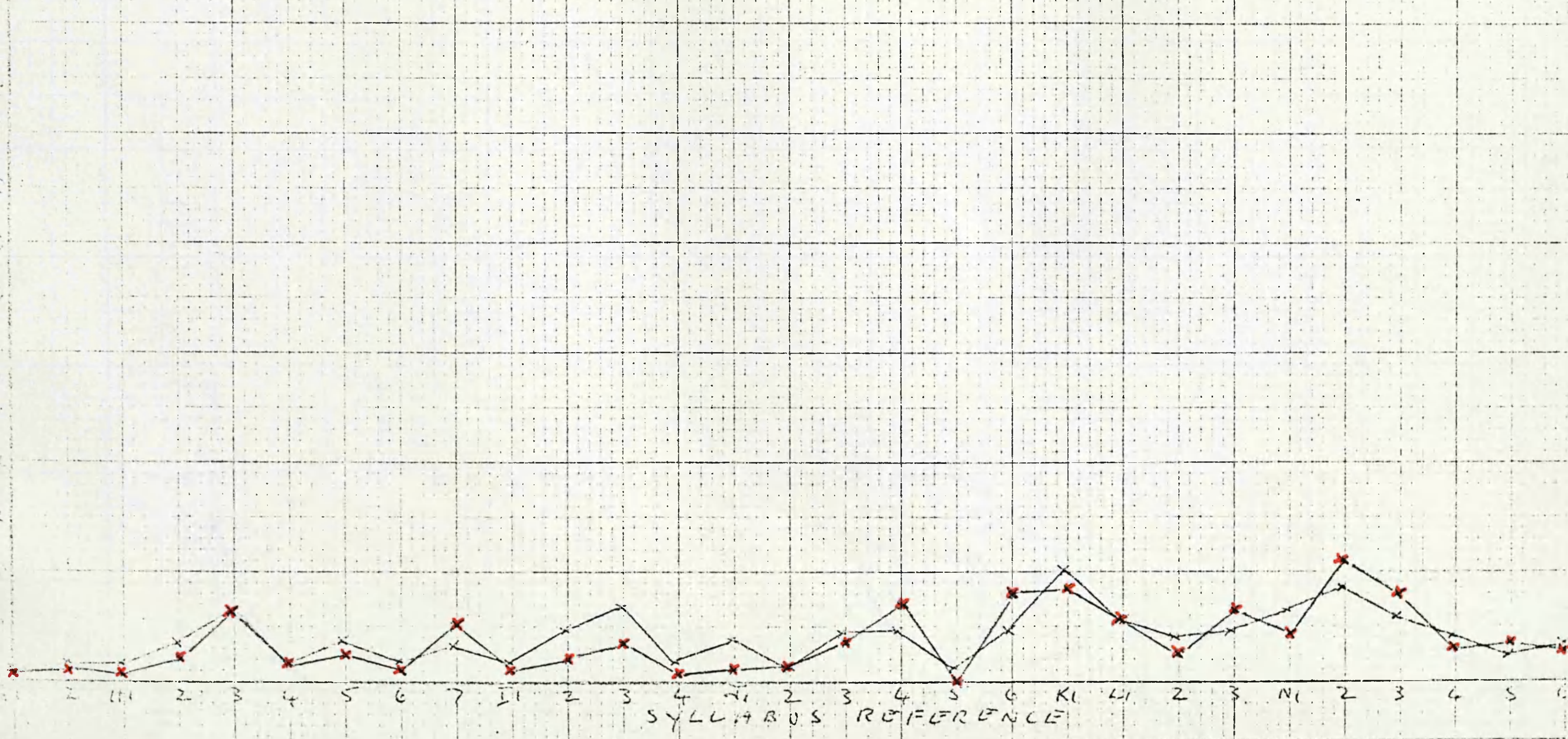
(b) "Difficult to Grasp" Topics - 1971-72 Students.



GRAPHS 3(a) and (b).

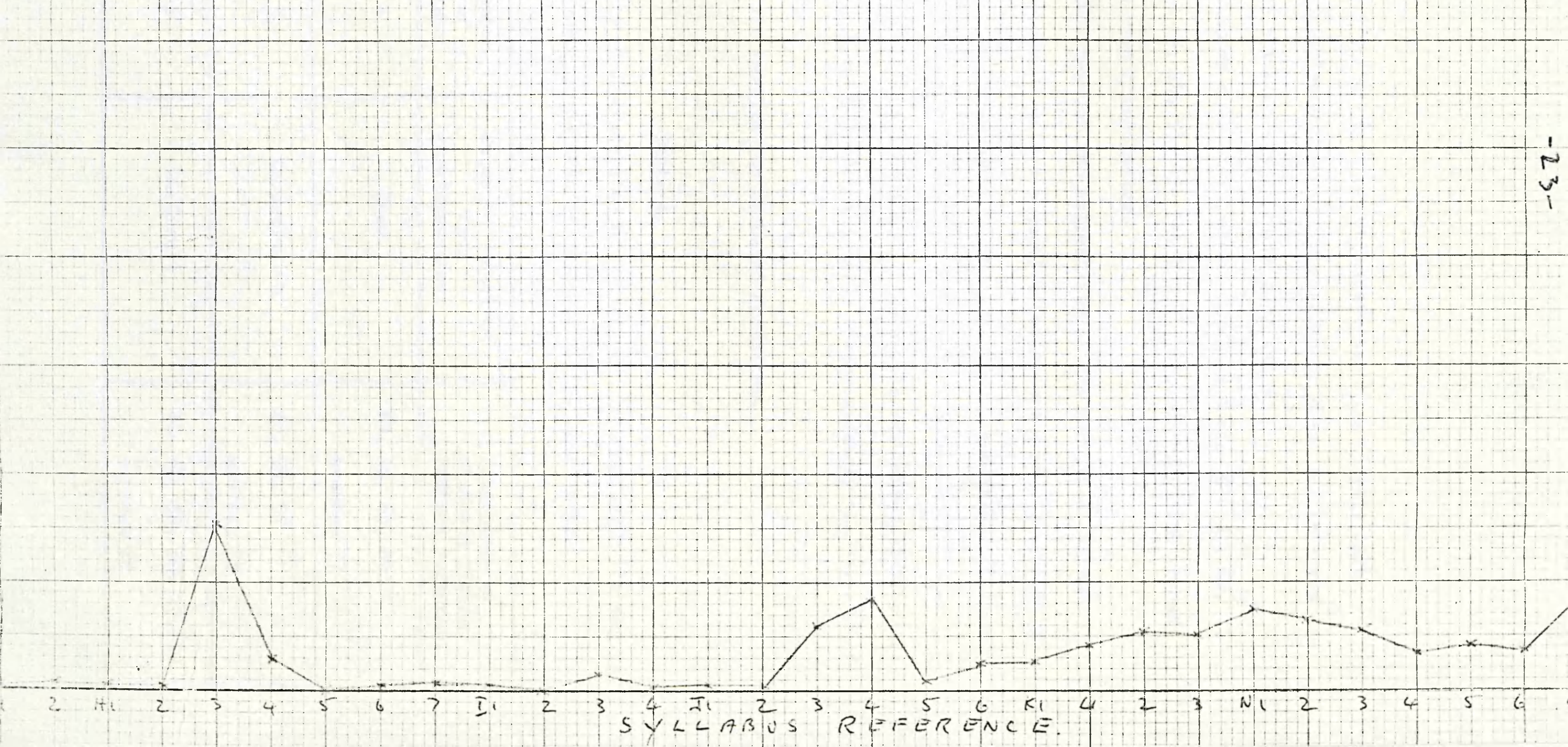
(a) "Never Really Grasped" Topics - 1970-71 Students.

(b) "Never Really Grasped" Topics - 1971-72 Students.



GRAPH 4

"Did Not Cover" Topics - 1971-71 Students.



Comment.

The results of the 1970-71 students' responses have already been published.[13] The comparisons between the results of these students and the 1971-72 students are striking - see Graphs 1, 2 and 3.

In general, students feel that they had grasped topics G1, H1, H4, I1, I4, J2 and J5, while H3, H7, I3, J3, J4, J6, K1, N2, N3 and O1 had caused difficulty. Others were inconclusive.

As an independent test of the reliability of the results of these questionnaires, the results of six objective tests, set quite independently of this research by the S.C.E. Examination Board, were analysed. These tests, which were pretests for a later national examination, covered the same areas of work as the questionnaires. The sample was representative of the whole ability range of O-grade candidates - approximately the top 40% of the school population.

Table 4 shows the results for selected questions.

Table 4.

Comparison of results of O-grade students in objective tests, with the degree of difficulty they thought they had experienced in the same topics.

Syllabus Reference of topic.[1]	Number of items.	Students' Reaction from questionnaires.	Percentage of students giving correct response.
G1	4	Easy	69, 85, 63, 89 average 77
H2	3	Inconclusive	46, 55, 57 average 53
H3	6	Difficult	10, 40, 38, 30, 27, 27 average 29

I1	4	Easy	45, 75, 56, 59 average 59
I3	4	Difficult	35, 49, 46, 30 average 40
L3	4	Inconclusive	45, 54, 24, 50 average 43
N1	2	Inconclusive	51, 53 average 52
N2	3	Difficult	30, 31, 32 average 31
N6	3	Inconclusive	78, 43, 45 average 55

Some agreement between the stated difficulties of the pupils and their test performance is apparent.

The objective test items chosen for analysis conformed to each of the following criteria:-

1. Those which in the judgement of a group of experienced setters were good and fair, despite the fact that not all of them had facility values falling between 0.35 and 0.85. (This subjective judgement on an objective test may seem odd, but those who have compiled objective tests know only too well how subjective their construction can be).
2. Those in which all distractors functioned - each drawing at least 5% of the responses.
3. Those which had a biserial correlation between 0.3 and 0.5

The areas of difficulty, and some possible reasons.

Problems seem to fall into two areas, and their nature requires examination.

First, pupils seem to be reasonably happy about their ability to write chemical formulae and to calculate formula weights, but they are much less confident about writing equations and carrying out calculations based on them. It might be that formula writing is a skill which can be acquired with little or no knowledge of chemistry, whereas the student must know some chemistry to be able to write an equation. Perhaps unnecessary emphasis is being laid on balanced molecular equations, and the quantitative significance of an equation is being misunderstood.

Organic chemistry appears to be a second general area of difficulty. Whatever the reasons for this, one contributory factor is already clear. Much of the organic part of the course is close to the end of the printed syllabus [1] and, although teachers are free to teach the syllabus in any order they choose, the majority keep to the printed order.

Students indicated in the questionnaires that the organic chemistry topics were either rushed or omitted. This factor is indicated in Tables 2 and 3 where the early organic topics such as L1, L2 and L3 are quite satisfactory, but later topics seem to present more difficulty.

It is of particular interest that A.H. Johnstone reported [4] some coincident areas of difficulty, H7 J6 K1 N2 and N3, in studies made of first year University students' reactions to their school chemistry courses.

The author has a long experience (since 1954) of teaching chemistry at various levels, and during the writing of the "Chemistry Takes Shape" series of school chemistry textbooks, [14] particular attention was paid to known areas of difficulty, judged subjectively by experience. With very few exceptions, the areas of difficulty were those reported by the students cooperating in this research.

Why are there so many areas of difficulty for so many pupils? It cannot all be laid at the door of bad teaching on the part of the teachers, and inattention on the part of the pupils. Are we trying too much, too early? Have we got the order wrong? Is it a matter purely of quantity, or are the techniques of thought asked of our pupils of chemistry too sophisticated?

Are we expecting pupils to "make bricks without straw"? Have we cut out too many facts? Have we eliminated too much data? These thoughts are prompted by the following extract from "How Children Learn" by John Holt.

> "It doesn't take a child long, by such steps, to grasp the basic idea of the cello, the relationship of the bow, the string, and the left hand. But while he has been figuring this out, he has been ceaselessly active. One could say that he is having too much fun - a weak work, really - playing the cello to want to take time to figure it out. A scientist might say that, along with his useful data, the child has collected an enormous quantity of random, useless data. A trained scientist wants to cut all irrelevant data out of his experiment. He is asking nature a question, and he wants to cut down the noise, the static, the random information, to a minimum, so that he can hear the answer. But a child doesn't work that way. He is used to getting his answers out of the noise. He has, after all, grown up in a strange world where everything is noise, where he can only understand and make sense of a tiny part of what he experiences. His way of attacking the cello problem is to produce the maximum amount of data possible to do as many things as he can, to use his hands and the bow in as many ways as possible. Then, as he goes along, he begins to notice regularities and patterns. He begins to ask questions - that is, to make deliberate experiments. But it is vital to note that until he

has a great deal of data, he has no idea what questions to ask, or what questions there are to be asked."

Further reasons for the existence of so many areas of difficulty may also be found by referring to the work on educational thought carried out by Piaget. It is doubtful if this work has had a measurable affect on educational practice, particularly with regard to the suggested three main periods of cognitive development:-

1. Stage 1 - extending from birth to about 18 months.
2. Stage 2 - continues until about the end of S2 (13 years).
3. Stage 3 - is not complete until about S5 (16 years). This is the stage during which the majority of the O-grade work has to be handled.

Now the topics found "Difficult to Grasp" or "Never Really Grasped", by both the 1970-71 and 1971-72 students are:-

H3. Using the ion detector to measure the conductivity of solutions, and understanding the results.

H7. Calculations from equations.

I3. Electron transfer in oxidation-reduction (redox) reactions.

J3. The various methods of preparing soluble salts.

J4. Precipitation reactions for preparing insoluble salts.

J6. Calculations to find the molarity of a solution.

K1. Ion-electron half-equations. The meaning of equations like

$$SO_3^{2-} + H_2O \rightarrow SO_4^{2-} + 2H^+ + 2e$$

and $$3e + NO_3^- + 4H^+ \rightarrow NO + 2H_2O$$

N2. The formation of esters.

N3. The conversion of fats to soaps.

O1. Making condensation polymers, e.g. nylon, phenol-formaldehyde.

Sections H3, I3 and K1.

Apart from meter readings, there is little concrete here on which pupils can build. Rather is it hypothetical thinking which is required. There is also a need to think about the effect of a number of variable factors upon a situation. These are skills which are slow to develop in Stage 3, and one may be expecting too much from the majority of O-grade pupils, particularly when we attempt this work during S3. Conceptually the ideas involved are probably too difficult. In addition, there seems to be too much for a pupil to hold in his mind and to be recalled when the occasion demands.

It is noticed also that Section H3 was high in the "Did not Cover" responses from the 1971-72 students.

Sections H7 and J6.

This work involves both chemistry and arithmetic - a fusion of which has given trouble for generations. It is possible that a different approach to the setting down of such problems on the part of teachers of chemistry, might improve the situation.

The following example would be expected to give most pupils a great deal of trouble.

"What volume of 2 M sulphuric acid will neutralise 20 ml of 0.5 M sodium hydroxide solution?"

The lay out of the answer which follows is suggested as one which pupils would find easier to follow and to apply to similar situations. This automatic type of approach is the kind of response expected of junior laboratory trainees in industry. They do the titration - or use an automatic titrimeter - and apply a formula.

For very able pupils, a more reasoned approach may be required, but not necessarily at this point in S3. Somewhere in S5 or S6 would probably be a better place to go into this more fully.

$$2NaOH + H_2SO_4 \longrightarrow Na_2SO_4 + 2H_2O$$

2 moles   1 mole

2000 ml M   1000 ml M

Conc. NaOH(M)	Vol. NaOH(ml)		Vol. H_2SO_4(ml)	Conc. H_2SO_4(M)
0.5	20			
1	$20 \times \frac{0.5}{1}$			
1	10	$\equiv$	5	1
			$5 \times \frac{1}{2}$	2
			2.5	2

$\Rightarrow$ 2.5 ml 2M H_2SO_4 are required.

Setting down such problems this way, involves having to deal with only one variable factor at a time. The equivalence sign, $\equiv$, could still be retained for use in this situation although it is not used in school mathematics, because there is no reliable substitute. Use of this sign by chemistry pupils would emphasise that this is the main chemical step in the solution.

A similar layout is suggested for solving problems concerning the masses of substances involved in chemical reactions.

E.g. "What mass of calcium oxide would be obtained by roasting 8 g of calcium carbonate?"

$$Ca\,CO_3 \longrightarrow CaO + CO_2$$

Mass Ca CO_3(g)	Mass Ca O(g)
100	56
8	$56 \times \frac{8}{100}$
8	4.48

$\Rightarrow$ 4.48g of calcium oxide are obtained.

These are routine formats with which pupils are familiar in present day elementary mathematics. Only one variable factor has to be dealt with at a time.

The author and colleagues are presently presenting chemical arithmetic to pupils in S3 and S4 in this way, and while concrete figures are not yet available, indications to date are that more pupils are solving more problems of this kind than hitherto.

Sections J3 and J4.

These sections require experience in practical work and more familiarity with chemical techniques than is found in pupils at the S3 stage.

It could be that this work is rushed in schools, as well as being attempted too early in most courses.

Sections N2, N3 and O1.

This is organic chemistry which is very often done in school at the end of the course - a point which has been made before. If any topics have to be rushed, or omitted, it is generally the organic work which suffers. It is noted that these sections are high in the "Did not Cover" responses from the 1971-72 students.

The areas found "Easy to Grasp".

The topics found "Easy to Grasp" by both the 1970-71 and 1971-72 students are:-

G1. Atomic particles and their arrangement in the atom.

H1. The chemical combination of elements to form compounds.

I1. The idea of a reactivity series of metals.

I4. Corrosion of metals. The idea of sacrificial protection.

J2. What is meant by the pH of a solution.

J5. Using an indicator to tell when an acid has neutralised an alkali.

Sections G1 and H1.

These topics are pictorial and concrete. Models are widely used. There is a clear pattern which follows the Periodic Table.

Sections I1 and I4.

This work involves the handling of a limited number of metals, most of which are familiar. There is constant reinforcement from numerous experiments, and constant reference to the reactivity series in subsequent work. Corrosion is an everyday chemical experience, and both topics are related.

Sections J2 and J5.

In these sections little understanding is required and no mathematics. The pH scale results from concrete operations, and neutralisation follows directly from it. No feats of memory are required and any thinking can be related directly to experiment. The sections also contain work which has been introduced in S2.

Graph 4.

The topics which some of the 1971-72 students "Did not Cover" at school are H3, J3, J4 and almost everything from L1 onwards. One only can conjecture at the reasons, since concrete evidence is lacking.

The use of the ion detector is relatively new in schools, while the preparation of salts, in the teaching experience of the author, may not be allocated sufficient time.

It is clear that if work is omitted at school, then the organic part of the work suffers most.[4] It has been suggested that this is so because the work normally is carried out toward the end of most O-grade courses. Certainly it is hard to believe that teachers consider it too be the least important part of the course. There is, currently, an increasing tendency on the part of many teachers to deal with the organic part of the syllabus in S3, instead of towards the end of S4 as hitherto - a point which has been mentioned before.

T.V. Howe is presently engaged in research work which involves a comparison between the performances of matched groups of pupils, to whom the O-grade syllabus has been taught in a different sequence. The publication of results is awaited with great interest, although preliminary work by A.H. Johnstone and K. Urquhart [27] suggests that only in organic topics is there any significant difference in pupil performance as a result of this rearrangement.

Pupil Practical Work.

Normally four periods per week are allocated to chemistry in S3 and S4 at school. Is this sufficient time in which to cover the course adequately? If any "soft pedalling" has to be done in school, it is likely that pupil practical will be first to be curtailed.

The responses to the additional question in the 1971-72 questionnaire showed the following situation regarding the amount of practical work done.

Too much	2%
Too little	56.5%
Sufficient	41.5%

It seems that despite the hopes of the syllabus planners, there is still insufficient pupil practical work being carried out in many schools (see p.35). Is this due to lack of time or to lack of inclination?

B. Reactions to O-1 Chemistry Course.

In August 1971, 200 students, in nine F.E. Colleges, who had completed their first year at College in June 1971, were invited to comment on their O-1 chemistry course. All these students had passed the O-1 chemistry examination and all had indicated an intention to proceed to the O-2 course. Because this sample contained none of the failed students, the results will be rather more favourable to the course.

The questionnaire which they were asked to complete is shown at appendix

2, 3. Questions related to a comparison of O-grade chemistry with O-1 chemistry, and to some observations concerning the objectives behind their practical work, together with some questions covering both the presentation and content of their O-1 course.

The questionnaire was repeated with another 200 students who had completed their O-1 course in 1972 and who intended to proceed to the O-2 course thereafter.

The results of these questionnaires follow. Unless otherwise stated, the figures are percentages of the total response.

1. A comparison between O-1 course[2] and O-grade course.[5]

The O-1 course was:-	1970-71 Students	1971-72 Students
More enjoyable	42	31
Less enjoyable	20	26
About the same	38	43

2. Was an O-grade pass in chemistry a sufficiently high entrance qualification for the O-1 course?

	1970-71 Students	1971-72 Students
Yes	60	62
No	34	33
Don't know	6	5

3. How did the pace of O-1 course compare with the pace of the O-grade course.

The O-1 course was:-	1970-71 Students	1971-72 Students
Faster	80	81
Slower	6	5
About the same	14	14

4. The amount of practical work in the O-1 course compared with that in the O-grade course.

The O-1 course contained:-

More	68	62
Less	16	23
About the same	16	15

Despite the subjective nature of the responses, the similarities between the 1971 results and those of 1972 are impressive. This gives more weight to the supposition that the results of the questionnaires reflect genuine reaction on the part of the pupils.

Comment.

Despite the fact that so many of the students felt the increased pace of the O-1 course, few thought that the course was less enjoyable than their course at school. One wonders how much these reactions are influenced by the greater amount of practical work done during the O-1 course.

D. Gunning and C.A. Wood are presently engaged in an evaluation of practical work in school chemistry courses. Preliminary results to date[16] from 78 schools show that although the S.C.E. Examination Board syllabus for O-grade chemistry suggests 82 pupil experiments, 35 of these schools allow pupils to carry out less than 50 pupil experiments. Indeed two schools allow pupils to carry out only 10-14 experiments in two years! These results, even at an early stage in the evaluation, bear out the comments which have been made already (see p. 33) concerning the amount of pupil practical work being carried out in schools. It is interesting to find that so many of the students felt that a S.C.E. pass at O-grade was a sufficiently high entrance qualification to the O-1 course, more particularly since the vast majority of the students involved had pass marks in the lower bands. This point is made clear in chapter 1.

The students' reactions to their practical work in the laboratory, during their O-1 course, are given in the following results of question 5.

5. Has your laboratory work given you

	1970-71 Students			1971-72 Students		
	Yes	No	Don't Know	Yes	No	Don't Know
(a) an enthusiastic inquisitive attitude to chemistry?	41	41	18	30	52	18
(b) the ability to observe accurately?	74	18	8	63	21	16
(c) a knowledge of the different laboratory techniques?	89	9	2	84	13	3
(d) an opportunity to <u>apply</u> your knowledge of chemistry?	62	31	7	54	38	8
(e) assistance to develop a safety conscious attitude?	60	30	10	59	33	8
(f) the ability to follow oral and written instructions?	78	16	6	74	22	4

Comment.

Few students did not venture an opinion concerning the suggested objectives, and the evident failure of the practical work to give the students an enthusiastic inquisitive attitude to chemistry is disappointing.

Little more than half the students felt that the laboratory work provided an opportunity to apply their chemical knowledge, and a fairly high percentage felt that the work had not developed a safety conscious attitude.

6. In view of the responses to the previous question, it is not

surprising that when asked which part of the laboratory course they found most difficult to master, one of the greatest single difficulties reported was "The writing up of laboratory reports". The greatest single difficulty reported by those students who responded to this question was "Calculations and Results". Difficulties such as these understandably fail to engender an enthusiastic inquisitive attitude to chemistry.

Three other difficulties were stated more frequently than others:-

(i) "Following Experimental Instructions", which is related to the difficulties reported above.

(ii) "Finding the necessary apparatus".

(iii) "Organic work generally".

One wonders whether the nature and presentation of the laboratory work could be investigated, with a view to minimising the problems which students have, concerning execution and reporting.

The lack of practice in work such as this at O-grade level is commented upon in chapter 3.

	1970-71 Students	1971-72 Students
7. Was any tutorial work included in your course?		
Yes	89	77
No	11	23
8. If "Yes", did you find it helpful or not?		
Helpful	84	81
Not helpful	5	9
Uncertain	11	10

9. Were regular home exercises a part of your O-1 course?

Yes	63	61
No	37	39

Comment.

The amount of tutorial work being attempted is worthy of note - as is the students' view that this type of work is helpful to them. Perhaps they should have been asked also about the helpfulness of the regular home exercises.

10. How were the lecture notes given to you?

	1970-71 Students	1971-72 Students
Dictated	13	18
Duplicated notes issued	13	10
Copied from the blackboard	4	6
A mixture of all three above	70	66

11. How do you prefer to get your lecture notes?

Dictated	15	22
Duplicated notes issued	33	24
Copied from the blackboard	10	11
A mixture of all three above	42	43

Comment.

Students seem to favour the issue of more duplicated notes, and both positive and negative arguments could be made in their favour. Clearly a fair amount of note giving still takes place. It is interesting to see that in both of these questions, the second year results show a slight increase in dictated notes and a decrease in the percentage of students receiving duplicated notes.

12. Have you found your O-1 course

	1970-71 Students	1971-72 Students
Easy	10	9
Reasonable	83	75
Difficult	7	16

13. Have you found your O-1 course

	1970-71 Students	1971-72 Students
Stimulating	15	12
Boring	22	30
Neither	63	58

Comment.

Although the vast majority of students found the course reasonable (as expected) it is disappointing that such a high percentage indicated that it was boring. But despite this response, these students had embarked on an O-2 course! In the light of these figures, the success or otherwise of these students in the O-2 examination was thought to be worth following up. The point is returned to in chapter 4.

14. This question related to the level of difficulty which students found concerning some of the main topics which had been covered during the O-1 course.

	1970-71 Students				1971-72 Students			
	Easy	Reason-able	Diffi-cult	Never Under stood	Easy	Reason-able	Diffi-cult	Never Under stood
Atomic structure - s, p, d and f orbitals - electron energy levels.	32	55	11	2	36	41	15	8
Bonding - covalent and ionic structure of molecules - properties of ionic and covalent substances.	23	65	11	1	22	66	11	1
Energetics - Heats of reaction - Hess' Law - Energy of Activ-ation - catalysis - equilibium.	22	54	23	1	20	48	30	2
Group and period trends in the Periodic table - valency and oxidation state.	15	53	31	1	17	50	29	4

Organic chemistry - the structures and characteristics of carbon containing compounds.	32	49	18	1	25	52	19	4

Comment.

The similarity between the responses from the two groups of students is striking, and one would hope that the lecturers teaching the 0-1 course would benefit from the knowledge.

Moreover, since these are the views of students who had gone on to take the 0-2 course, their problems probably were magnified many times over in the case of the students who did not pass the 0-1 examination, and who had not continued with further study of the subject.

An investigation into specific problem areas at a similar level - S.C.E. Examination Board H-grade chemistry - has been carried out by A.H. Johnstone and others.[13] The areas of difficulty reported by students who had taken this course and who had proceeded to further study at a University, were broadly similar to the above results.

15. Here are some topics which people have found difficult to understand when they were introduced to them at school. Do you now find them easier to understand or not?

	1970-71 Students		1971-72 Students	
	Easier	No Difference	Easier	No Difference
Calculations to find molarities of solutions.	51	49	48	52
Calculations from equations.	61	39	46	54
The method of precipitation to form an insoluble salt.	46	54	32	68
Redox reactions - the meaning of ion-electron half equations. e.g. $MnO_4^- + 8H^+ + 5e \rightarrow Mn^{2+} + 4H_2O$	41	59	39	61

The formation of esters.	36	64	28	72

Comment.

It is disappointing to note the very high percentages of "No Difference" responses.

One of the reasons is clear, and numerous lecturers in F.E. Colleges have commented upon it in their views which are analysed in chapter 3. This is, that much of the work covered at O-grade is not met again until the O-2 stage.

As one lecturer put it, "Some of the topics are dealt with more thoroughly at the O-2 stage, but by this time the student has been away from it for an academic year." Perhaps O-1 syllabus planners might take this into account.

But clear problem areas remain. Teachers and lecturers should find these areas of interest.

16. Are there any parts of your lecture course not covered in question 14 which you feel that you have not yet understood?

Extremely few students took advantage of this question. The only topic which a few students admitted to never having understood (11 students in 1970-71, and 8 in 1971-72) was hybridisation. The writer can sympathise!

Appendix to Chapter 2.

APPENDIX 2, 1.

UNIVERSITY OF GLASGOW

Research in Chemical Education

We are trying to find out something about your reactions to the O-grade chemistry course which you completed recently at school. We are also interested in your reasons for continuing with the study of chemistry at this College.

We would like you to answer the following questions carefully and seriously. The results will be of value when any changes in school chemistry courses are considered.

Name ______________________________

Secondary School attended ______________________________

1. Have you a S.C.E. Examination Board Pass in O-grade chemistry (alternative)? (Tick the appropriate box.)

   Year of pass [19] yes [ ] no [ ]

2. What job do you intend to do when you leave College?

   ______________________________ (If uncertain please say so).

3. Why did you study chemistry during your third year and beyond, in secondary school? (Tick the box, or boxes below which apply.)

   (a) a definite liking for chemistry [ ]
   (b) no other subject could be taken in its place [ ]
   (c) good examination results in science in years one and two [ ]
   (d) wanted to prepare for a job which involved chemistry [ ]
   (e) teachers at school pressed you to take it [ ]
   (f) parents pressed you to take it. [ ]

   If you studied chemistry at school for any other reason, please state the reason or reasons now. ______________________________

4. Did you first detect a liking for science in general in

   (a) primary school? [ ]
   (b) early secondary school? [ ]
   (c) late secondary school? [ ]

   Tick the box which applies.

5. Do you think that there are any particular reasons for your interest in chemistry? (Place a tick in whichever boxes apply.)

(a) seeing a lot about chemistry on television ☐

(b) books which you have read ☐

(c) a good teacher at school ☐

(d) an interesting course in chemistry at school ☐

(e) father's job involved chemistry. ☐

If there are any other reasons, please state them now _ _ _ _ _ _ _ _ _ _ _ _

_ _

6. Some of the topics which you studied in your school course are listed below. Tick your opinion of how you found each topic.

	Easy to Grasp	Difficult to Grasp	Never Really Grasped
G1. Atomic particles and their arrangement in the atom.			
G2. The idea of isotopes.			
H1. The chemical combination of elements to form compounds.			
H2. The differences between covalent and electrovalent (ionic) bonding.			
H3. Using the ion detector to measure the conductivity of solutions, and understanding the results.			
H4. Writing chemical formulae.			
H5. Writing chemical equations.			
H6. Calculating the formula weight of a compound.			
H7. Calculations from equations.			
I1. The idea of a reactivity series of metals.			
I2. The ionisation of water. The meaning of $H_2O - H^+(aq) + OH^-(aq)$.			
I3. Electron transfer in oxidation-reduction (Redox) reactions.			
I4. Corrosion of metals. The idea of sacrificial protection.			

		Easy to Grasp	Difficult to Grasp	Never Really Grasped
J1.	Acidic and basic oxides.			
J2.	What is meant by the pH of a solution.			
J3.	The various methods of preparing soluble salts.			
J4.	Precipitation reactions for preparing insoluble salts.			
J5.	Using an indicator to tell when an acid has neutralised an alkali.			
J6.	Calculations to find the molarity of a solution.			
K1.	Ion-electron half-equations. The meaning of equations like $SO_3^{2-} + H_2O \rightarrow SO_4^{2-} + 2H^+ + 2e$ and $3e + NO_3^- + 4H^+ \rightarrow NO + 2H_2O$			
L1.	The "cracking" of liquid hydrocarbons.			
L2.	The distillation of crude oil to give a number of fractions.			
L3.	The making of addition polymers, e.g. perspex, polystyrene, P.V.C.			
N1.	The breaking down (hydrolysis) of carbohydrates using saliva or hydrochloric acid.			
N2.	The formation of esters.			
N3.	The conversion of fats to soaps.			
N4.	How soaps and detergents clean.			
N5.	Why a scum sometimes forms when soap is used for washing.			
N6.	The importance of nitrogen containing compounds.			
O1.	Making condensation polymers, e.g. nylon, phenol-formaldehyde.			

Thank you for your help in completing this questionnaire.

APPENDIX 2, 2.

UNIVERSITY OF GLASGOW

Research in Chemical Education

We are trying to find out something about your reactions to the O-grade chemistry course which you completed recently at school. We are also interested in your reasons for continuing with the study of chemistry at this College.

We would like you to answer the following questions carefully and seriously. The results will be of value when any changes in school chemistry courses are considered.

Name _

Secondary School attended _

1. Have you a S.C.E. Examination Board Pass in O-grade chemistry (alternative)? (Tick the appropriate box.)

   Year of pass [19]

   yes [ ]

   no [ ]

2. What job do you intend to do when you leave College?

   _ (If uncertain please say so.)

3. Why did you study chemistry during your third year and beyond, in secondary school? (Tick the box, or boxes below which apply.)

   (a) a definite liking for chemistry [ ]

   (b) no other subject could be taken in its place [ ]

   (c) good examination results in science in years one and two [ ]

   (d) wanted to prepare for a job which involved chemistry [ ]

   (e) teachers at school pressed you to take it [ ]

   (f) parents pressed you to take it [ ]

   If you studied chemistry at school for any other reason, please state the reason or reasons now.

   _

4. Did you first detect a liking for science in general in

   (a) primary school? [ ]

   (b) early secondary school? [ ]

   (c) late secondary school? [ ]

   Tick the box which applies.

5. Do you think that there are any particular reasons for your interest in chemistry? (Place a tick in whichever boxes apply.)

(a) seeing a lot about chemistry on television

(b) books which you have read

(c) a good teacher at school

(d) an interesting course in chemistry at school

(e) father's job involved chemistry.

If there are any other reasons, please state them now _ _ _ _ _ _ _ _ _ _ _ _

_ _

6. Some of the topics which you studied in your school course are listed below. Tick your opinion of how you found each topic.

	Easy to Grasp	Difficult to Grasp	Never Really Grasped	Did not Cover
G1. Atomic particles and their arrangement in the atom.				
G2. The idea of isotopes.				
H1. The chemical combination of elements to form compounds.				
H2. The differences between covalent and electrovalent (ionic) bonding.				
H3. Using the ion detector to measure the conductivity of solutions, and understanding the results.				
H4. Writing chemical formulae.				
H5. Writing chemical equations.				
H6. Calculating the formula weight of a compound.				
H7. Calculations from equations.				
I1. The idea of a reactivity series of metals.				
I2. The ionisation of water. The meaning of $H_2O \rightarrow H^+(aq) + OH^-(aq)$.				
I3. Electron transfer in oxidation-reduction (Redox) reactions.				
I4. Corrosion of metals. The idea of sacrificial protection.				

		Easy to Grasp	Difficult to Grasp	Never Really Grasped	Did not Cover
J1.	Acidic and basic oxides.				
J2.	What is meant by the pH of a solution.				
J3.	The various methods of preparing soluble salts.				
J4.	Precipitation reactions for preparing insoluble salts.				
J5.	Using an indicator to tell when an acid has neutralised an alkali.				
J6.	Calculations to find the molarity of a solution.				
K1.	Ion-electron half-equations. The meaning of equations like $SO_3^{2-} + H_2O \rightarrow SO_4^{2-} + 2H^+ + 2e$ and $3e + NO_3^- + 4H^+ \rightarrow NO + 2H_2O$				
L1.	The "cracking" of liquid hydrocarbons.				
L2.	The distillation of crude oil to give a number of fractions.				
L3.	The making of addition polymers, e.g. perspex, polystyrene, P.V.C.				
N1.	The breaking down (hydrolysis) of carbohydrates using saliva or hydrochloric acid.				
N2.	The formation of esters.				
N3.	The conversion of fats to soaps.				
N4.	How soaps and detergents clean.				
N5.	Why a scum sometimes forms when soap is used for washing.				
N6.	The importance of nitrogen containing compounds.				
O1.	Making condensation polymers, e.g. nylon, phenol-formaldehyde.				

7. Do you feel that your chemistry course at school contained too much practical work for you to do yourself, too little, or that the amount of practical work which you did was sufficient?

Too much	
Too little	
Sufficient	

Thank you for your help in completing this questionnaire.

APPENDIX 2, 3.

UNIVERSITY OF GLASGOW

Research in Chemical Education

When you commenced the 0-1 Chemistry course in this college in August, 1971, you were asked to complete a questionnaire concerning your reactions to your school course in Chemistry.

Now that you have completed your first year at....................Technical College, we would like you to cooperate further by answering the following questions carefully and seriously.

Where relevant, please indicate your answer by placing a tick (✓) in the appropriate box.

(1) How has your 0-1 Chemistry course compared with your Chemistry course at school?

More enjoyable	
Less enjoyable	
about the same	

(2) Do you feel that the possession of an O-grade pass in Chemistry from school was a sufficiently high qualification to allow you to commence the 0-1 course in Chemistry at Technical College?

Yes	
No	
Don't know	

(3) Has there been more or less practical work in your 0-1 course than in your O-grade course at school?

Faster	
Slower	
about the same	

(4) Has there been more or less practical work in your 0-1 course than in your O-grade course?

More	
Less	
about the same	

(5) The following are some stated reasons for including practical work in the laboratory in your course. Please indicate whether or not you feel that your laboratory work has benefited you in the ways suggested.

	Yes	No	Don't Know
(a) It has given you an enthusiastic inquisitive attitude to Chemistry.			
(b) It has given you the ability to observe accurately.			

	Yes	No	Don't Know
(c) It has given you a knowledge of the different laboratory techniques			
(d) It has given you an opportunity to apply your knowledge of Chemistry			
(e) It has helped you to develop a safety conscious attitude			
(f) It has given you the ability to follow oral and written instructions			

(6) Which part of your laboratory course have you found most difficult to master? (Please indicate on the dotted line).

....

(7) Have you had any tutorial work included in your course?

Yes ☐
No ☐

(8) If the answer to (7) above is 'Yes', indicate whether you found the tutorial work helpful or not.

Helpful ☐
Not Helpful ☐
Uncertain ☐

(9) Were regular home exercises a part of your 0-1 course?

Yes ☐
No ☐

(10) How were your lesson (lecture) notes given to you during your 0-1 course?

Dictated ☐
Duplicated notes issued ☐
Copied from the Blackboard ☐
A mixture of all three above ☐

(11) How do you prefer to get lesson (lecture) notes?

Dictated ☐
Duplicated notes issued ☐
Copied from the Blackboard ☐
A mixture of all three above ☐

(12) Have you found your O-1 course

Easy	
Reasonable	
Difficult	

(13) Have you found your O-1 course

Stimulating	
or Boring	
Neither	

(14) Here are some main topics covered during your O-1 course. Please indicate whether you found each group of topics easy, reasonable or difficult to understand, or even if you never understood them.

	Easy	Reasonable	Difficult	Never Understood
Atomic Structure - s,p,d and f orbitals - electron energy levels				
Bonding - covalent and ionic - structure of molecules - properties of ionic and covalent substances				
Energetics - Heats of Reaction - Hess' Law - Energy of Activation - catalysis - equilibrium				
Group and period trends in the Periodic Table - valency and oxidation state				
Organic Chemistry - the Structures and characteristics of carbon containing compounds				

(15) Here are some topics which most people found difficult to understand when they were introduced to them at school. Do you now find them easier to understand or not?

	Easier	No Difference
Calculations to find molarities of solutions		
Calculations from equations		
The method of precipitation to form an insoluble salt		
Redox reactions - the meaning of ion-electron half equations e.g. $MnO_4^- + 8H^+ + 3e \rightarrow Mn^{2+} + 4H_2O$		
The formation of esters		

(16) Are there any parts of your lecture course not covered in Q.14 which you feel that you have not yet understood? (Please indicate on the dotted lines).

....

....

....

Thank you for your cooperation in completing this questionnaire.

CHAPTER 3.

Chapter 3.

The Views of the Lecturers

It was suggested that the lecturers in the nine F.E. Colleges which were cooperating in this research, and who were involved in the teaching of the O-1 chemistry course, might be asked for their views concerning the preparation which the new school chemistry syllabus gave.

Questionnaires were sent to these lecturers - see Appendix 3, 1. Twenty-one replies were received. The results, together with some comments, are given below.

1. All the lecturers who had experience of teaching O-grade alternative chemistry agreed that it was more interesting to teach, more interesting to learn but more demanding on the teacher than the traditional syllabuses.

With regard to its effect on the pupils, opinion was divided. Only one quarter felt that the syllabus was more demanding on the pupil than the traditional one. The writer finds the majority opinion here hard to accept and to explain - unless it be that the lecturers involved are not in agreement with the aims of the new syllabus, and are judging the demands on the pupil by the amount of factual material which has to be recalled.

2. Opinion was also divided on the question if a S.C.E. pass in O-grade chemistry was a sufficiently high entrance qualification for an O-1 course.

Yes	70%
No	30%

It must be remembered that the majority of O-1 candidates are those who gained only a bare pass in O-grade. With this in mind the 70% figure is surprisingly high.

A future development by the S.C.E. Examination Board is that, from 1973, O-grade candidates who score upwards of 30% in the examination will be awarded an appropriate band letter, corresponding to the scaled mark scored in the examination, in accordance with Table 5.

Table 5

Band	A	B	C	D	E	No Award
Scaled Mark	70-100	60-69	50-59	40-49	30-39	0-29

It is a matter of conjecture how this change will effect the standard of future F.E. College entrants, but the Board have indicated that they consider this change will not affect the standard of the O-grade examination.

3. Do you find that your O-1 students have been unable to cover any specific areas of study during their O-grade course at school?

Yes	40%
No	60%

The specific areas mentioned most frequently by the 40% were:

H5. Writing chemical equations.

H7. Calculations from equations.

J6. Calculations to find the molarity of a solution.

L1-O1 "Parts of the organic work".

Since the first three of the above topics did not show up significantly in Graph 4 in chapter 1, but fairly high in Graphs 2(a) and (b), one wonders if the lecturers concerned read "master" for "cover".

It is the writer's experience that a view commonly held by those in tertiary education assumes that if a topic is mentioned in a syllabus, then it must have been mastered! There are several possible reasons why this is not so, and one would hope that F.E. lecturers would appreciate this. This point is commented upon in a paper, recently published by the Royal Society, entitled "Entry to Chemistry Courses at the Tertiary Level".[18]

However, with regard to the organic part of the course, the views of the lecturers do substantiate the remarks which have been made previously about omissions at many schools.

4. Do you feel that the O-grade school course has trained students sufficiently in practical skills?

Yes	17%
No	83%

Clearly the college lecturers felt that practical skills were not obvious in their students. In an attempt to discover the areas where the lack of practical skills was most obvious, lecturers were asked to specify areas where the absence of these skills was most apparent.

A general lack of manipulative talent was commented upon frequently - in assembling apparatus, in the use of specific pieces of apparatus and equipment such as the pipette, burette, and chemical balance. A claim was also made that students showed a lack of confidence when called upon to handle small quantities of chemicals. The feelings of one lecturer were expressed succinctly in the question "Do pupils ever carry out an experiment themselves?" while another showed his exasperation (or misunderstanding) by stating that the specific areas in which practical skills were lacking were "Too numerous to mention".

At first sight these views might give rise to serious misgivings about the way in which O-grade chemistry is being taught in schools. Indeed, in the light of the preliminary results of D. Gunning[16] to which reference has been made previously, these comments may not be far out!

But on reflection, one wonders if the strongest of these comments are fair, when considered in the light of the aims and objectives of the O-grade course.

Curriculum Papers7,[12] which covers only years S1 and S2, lists the following two practical skills which pupils should acquire as they follow the course, in its general objectives:-

(i) some simple science based skills, and

(ii) some experimental techniques involving several skills.

The S.C.E. Examination Board syllabus, however, does not lay any emphasis on the development of psychomotor skills in the seven listed aims of the syllabus.[1] The courses therein are more concerned with establishing a familiarity with ideas and with material, rather than in reaching a high standard in apparatus skills. After all, only a minority of pupils will ever require them.

One might argue that the requirements of F.E. should have more prominence in the establishing of specific objectives. But on the other hand it must be remembered that of the 100,000 pupils entering S1 in Scottish schools each year, less than 20,000 will sit the S.C.E. O-grade examination. Of the successful pupils, less than 500 enter O-1 chemistry courses in F.E. Colleges each year.[11]

While it could be conceded, especially in the light of the response of the students to Question 7 in appendix 2, 2, that more pupil practical work could be done in many schools, one has to distinguish between "education" and "training". If the skills are so important at the F.E. stage, one could argue that it is the place of the Colleges to teach them. In this connection it is interesting to note that since session 1969-70, suggested learning objectives have been included in the general foreword on laboratory work in chemistry, in the Schemes of Work published by S.A.N.C.A.D.[2] One of these (Number 6) reads:-

> "A knowledge of important laboratory techniques: the ability to use equipment efficiently and to interpret results."

Mastering laboratory techniques such as the use of a pipette, is work which can readily be accomplished by a student of 16 years. But it must be borne in mind that a school pupil can pass the O-grade examination comfortably without ever having seen such a piece of apparatus, let alone used one.

The whole matter of practical work and its assessment is a most interesting one which is almost permanently under study somewhere. In place of the impractical practical examination, work is presently in progress to devise paper and pencil tests of certain skills which would arise in practical work - such as safety, how things work, experimental design and the processing of results. J. McGuire, whose work is not yet published, is examining this as part of an investigation into practical work in the S.C.E. Examination Board's Certificate of Sixth Year Studies in Chemistry,[19] while J.G. Buckley and R.F. Kempa have published two interesting articles recently - "Practical Work in Sixth-form Chemistry Courses - an Enquiry"[20] and "Student preferences for different Methods of assessing Practical Work in Chemistry."[21] It will be interesting to see how these ideas develop.

5. Do you find that, in general, your O-1 students show an interest in:

		Yes	No
(a)	their practical work?	85	15
(b)	their theoretical work?	80	20
(c)	quantitative calculations?	15	85

The responses clearly indicate a lack of interest in calculations, a topic which was found, in chapter 2, to cause difficulty to students.

This lack of interest is probably due to the pupils' previous lack of success with such calculations. It highlights a well known problem among teachers and examiners as well as pupils, and substantiates the need for more research work in this field. Miss K. Urquhart is currently engaged on a research project dealing with problem solving in both mathematics and science, the results of which could prove extremely useful to teachers of chemistry.

6. The lecturers indicated that the understanding of the following topics was either "Less than adequate" or "Totally inadequate", in the students entering O-1 courses. The references within the brackets refer to the syllabus reference in appendices 2, 1 and 2, 2.

4 (H4.) Writing chemical formulae.

5 (H5.) Writing chemical equations.

6 (H7.) Calculations from equations.

7 (I3.) Electron transfer in redox reactions.

10 (-) The interconversion of salts.

11 (J6.) Calculations to find the molarities of solutions.

12 (K1.) Writing ion-electron half equations.

13 (K1.) Understanding ion-electron half equations.

16 (N1.) The hydrolysis of carbohydrates.

20 (N2.) The formation of esters.

22 (N4.) The mechanics of detergency.

23 (—) Why an ionic compound, such as Na^+Cl^- dissolves in water.

Of these 12 topics, 7 of them were stated by the majority of O-1 students to be "Difficult to Grasp" or "Never Really Grasped". Two of them had not been covered in the students' questionnaire. Of the remaining three topics, two (N1 and N4) had proved inconclusive from the students' responses, although they had felt that they had grasped topic H4.

9. Mention of syllabus objectives was made in the comments upon the responses of the lecturers to question 4. At the time of writing, no specific objectives have been published for the O-grade chemistry syllabus. The current syllabus[1] refers only to seven broad aims.

The lecturers, however, were provided with nine specific objectives (based upon unpublished work of the Central Committee on Science) for the O-grade chemistry syllabus, and were asked to indicate whether or not they agreed that each objective had been obtained.

		Yes	No
(a)	The ability to sift a great deal of given information and to select only that required to solve a given problem.	10	90
(b)	The ability to criticise statements in chemistry.	35	65
(c)	The ability to apply knowledge to unfamiliar problems.	30	70
(d)	The ability to design experimental arrangements in order to check predictions.	30	70
(e)	The ability to understand the importance of the presence of variable factors in an experimental situation.	45	55

		Yes	No
(f)	The ability to record results in graphical or diagrammatic form.	65	35
(g)	An awareness of the contribution of chemistry to the well-being of the country.	80	20
(h)	The ability to carry out oral and written experimental instructions.	75	25
(i)	The ability to work safely and cleanly, at the required speed.	30	70

While one must not read too much into the unsupported, subjective views of the lecturers, the results make interesting reading.

None of the objectives stated are knowledge objectives. Their order of complexity is higher. One would have hoped that the O-grade syllabus might have had more success in achieving the objectives stated, for which a greater depth of understanding is necessary than for purely knowledge objectives.

10. Almost half of the lecturers took the opportunity to state any additional personal comments which they felt might be useful. The following comments were found to occur most frequently, and it is suggested that teachers, lecturers and syllabus planners could learn from them. The first comment was by far the most common.

(i) "There should be a greater link between the O-grade syllabus and the O-1 syllabus."

Several of the lecturers commented that much of the O-grade work was not tackled in the F.E. Colleges until during the O-2 course, when the work which had been done at school was extremely hazy in the minds of the students - if it was there at all.

This comment seems to be justified.

(ii) "The communications between teachers and lecturers in many areas are poor."

Conferences do not seem to help very much. Could not some form of exchange between teachers and lecturers be beneficial to both, and to the students?

This point was raised at the first conference of the Education Division of the Chemical Society in Scotland. The main item which was praised was the chance to exchange views between teachers and F.E. lecturers.

The results of a questionnaire distributed at a conference on "Mastery", attended by F.E. Lecturers and held in Edinburgh, have been received by the writer.[22] The feeling of the conference seemed to be that the feature which interested most people attending was "Meeting and hearing the views and problems at other levels in chemistry teaching." One of the areas which many of the lecturers felt should be debated at future conferences was "School and University/Technical College interfaces."

It seems to the writer that much good could come from closer and more frequent communication between teachers and F.E. lecturers.

(iii) "There is a lack of real objectives concerning the O-grade course."

It is understood that such a set of specific objectives have been suggested by a working party drawn from the S.C.E. Examination Board's Chemistry Panel and the Scottish Central Committee for Chemistry.

(iv) "The students are poor at presenting a logical and neat report."

This is something at which the average O-grade pupil will have had little practice, but the second of the suggested learning objectives stated in the Schemes of Work published by S.A.N.C.A.D.[2] reads:-

"The ability to obtain, preserve and communicate information."

The presentation of a logical report is something which the student must learn in College, but the general lack of neatness among students at all stages is deplored.

5. "There is a lack of solid grounding in the interpretation of equations - the chemistry, not the arithmetic."

The interpretation of equations in the early stages has been a problem for chemistry teachers for some time. The entire question of how best to teach the topic of chemical equations at the S3 and S4 stages at school is presently being investigated by T.V. Howe. Some material has been published,[35] and it is hoped that this work will improve both the teaching and the understanding of the topic.

Conclusions

The results of the work outlined in this chapter, indicate that there is a gap between schools and F.E. Colleges, which needs to be closed. While some progress has been made in certain areas, it is felt that closer contact between these establishments is essential.

Appendix to Chapter 3.

Appendix 3, 1.

UNIVERSITY OF GLASGOW

Research in Chemical Education

Questionnaire for Lecturers in Technical Colleges

When completing this questionnaire would you kindly put a tick (✓) in the appropriate box.

1. Do you think that the present O-grade chemistry (alternative) syllabus is

(a) more interesting to teach than the traditional syllabus?	Yes	☐
	No	☐
(b) more interesting to learn than the traditional syllabus?	Yes	☐
	No	☐
(c) more demanding on the teacher than the traditional syllabus?	Yes	☐
	No	☐
(d) more demanding on the student than the traditional syllabus?	Yes	☐
	No	☐

2. Are you satisfied that, in general, a S.C.E. pass in O-grade chemistry is a sufficiently high "entrance qualification" for an O-1 course in chemistry?

Yes ☐

No ☐

3. Do you find that your O-1 students have been unable to cover any specific areas of study during their O-grade course at school?

Yes ☐

No ☐

If "Yes", please specify beneath the topics most commonly omitted.

Questionnaire for Lecturers in Technical Colleges

4. Do you feel that the O-grade school course has trained students sufficiently in practical skills?

Yes	
No	

If any particular skills seem to be absent, please specify them here.

5. Do you find that, in general, your O-1 students show an interest in

(a)	their practical work?	Yes		No	
(b)	their theoretical work?	Yes		No	
(c)	quantitative calculations?	Yes		No	

6. The following are specific areas in the present S.C.E. O-grade chemistry syllabus. Would you please indicate whether you find the understanding of students entering your O-1 course in chemistry to be more than adequate, adequate, less than adequate, or totally inadequate?

Topic	More than adequate	Adequate	Less than adequate	Totally inadequate
1. Atomic structure.				
2. The formation of covalent and ionic substances.				
3. The use of an "ion detector" to measure the conductivity of solutions, and the comprehension of the results.				
4. Writing chemical formulae.				
5. Writing chemical equations.				
6. Calculations from equations.				
7. Electron transfer in Redox reactions.				
8. The theory of corrosion in metals.				
9. The various methods of preparing salts.				

Topic	More than adequate	Adequate	Less than adequate	Totally inadequate
10. The interconversion of salts.				
11. The calculations to find the molarities of solutions.				
12. Writing ion electron half equations.				
13. Understanding ion electron half equations.				
14. Understanding the difference between symbols such as Cu and Cu^{2+}, Cl and Cl^- etc.				
15. The distillation of crude oil.				
16. The hydrolysis of carbohydrates.				
17. The hydrolysis of proteins.				
18. The formation of condensation polymers.				
19. The formation of addition polymers.				
20. The formation of esters.				
21. Soap formation.				
22. The mechanics of detergency.				
23. Why an ionic compound, such as Na^+Cl^-, dissolves in water.				
24. The nitrogen cycle and its importance.				

9. The following are some objectives which it has been suggested are attained by the present S.C.E. O-grade course in chemistry. Do you agree?

(a) The ability to sift a great deal of given information and to select only that required to solve a given problem. Yes ☐ No ☐

(b) The ability to criticise statements in chemistry. Yes ☐ No ☐

(c) The ability to apply knowledge to unfamiliar problems. Yes ☐ No ☐

(d) The ability to design experimental arrangements in order to check predictions. Yes ☐ No ☐

(e) The ability to understand the importance of the presence of variable factors in an experimental situation. Yes ☐ No ☐

(f) The ability to record results in graphical or diagrammatic form. Yes ☐ No ☐

(g) An awareness of the contribution of chemistry to the well-being of the country. Yes ☐ No ☐

(h) The ability to carry out oral and written experimental instructions. Yes [ ] No [ ]

(i) The ability to work safely and cleanly, at the required speed. Yes [ ] No [ ]

10. Have you any other relevant personal comments which you feel might help us in our assessment of the chemistry syllabuses in schools on Industrial Trainees in Scotland?

Yes [ ]
No [ ]

If "yes", can you please state them now.

Thank you for your assistance.

CHAPTER 4.

Chapter 4.

Comparisons of Performances.

Much has been said of the poor value of individual performances in O-grade examinations as a predictive tool in relation to performances in subsequent examinations. It was decided to test this view by comparing the performances of as many of the students as possible, in a number of examinations.

Students who entered the F.E. Colleges in August 1970 had their performances in either 2 or 3 examinations compared. These were, O-grade, O-1 and O-2 chemistry.

Students who entered the F.E. Colleges in August 1971 had their performances in O-grade and in O-1 chemistry compared.

A. The 1970 Entrants.

Correlation between performances in O-grade and O-1 chemistry.

Firstly the performance of each student in the S.C.E. O-grade examination in alternative chemistry was obtained. This was given a band mark, in accordance with Table 6.

Table 6.

% Mark	> 90	89-85	84-80	79-75	74-70	69-65	64-60	59-55	54-50	49-45	44-40	39-35	< 34
Band Mark	1	2	3	4	5	6	7	8	9	10	11	12	13

The students in each of the 9 Colleges were placed in an order of merit
O.M. (i) decided upon by their performance at O-grade. The bands show clearly

that few students possessed a very high band score at O-grade.

Next the mark of each student in O-1 chemistry was obtained. These marks were placed in the appropriate band - see Table 6 - and the students placed in a second order of merit (O.M. (ii))

The Spearman Rank Correlation Coefficient[23] (R) between these 2 orders of merit was calculated for each College.

However, since the O-1 chemistry examination is not a national one, it was decided to standardise these raw marks. Therefore the mean ($\bar{X}$) and standard deviation (S) for each College examination was calculated, and each mark was converted to a standard score, that is, to give a series of marks with a mean of 50 and a standard deviation of 10.

A mark (N) with a mean of zero and a standard deviation of 1, is found by

$$\frac{\text{Raw Score - Mean}}{\text{Standard Deviation}}$$

These marks are not easily recognisable as such, and the standardised score is given by

$$(N \times 10) + 50$$

where 10 is the "new" standard deviation, and 50 is the "new" mean.

These standardised scores were then used to produce a third order of merit (O.M. (iii)) after having been given the appropriate band mark - see Table 6. The Spearman Rank Correlation Coefficient[23] (R) between this order of merit and the order of merit on the O-grade results, also was calculated.

Results for each of the 9 Colleges follow.

Centre 1

Student	O-grade band	O.M. (i)	O-1 Mark	O-1 band	O.M. (ii)	O-1 Stand-ardised Mark	Band	O.M. (iii)
1	9	10.5	58	8	7	47	10	7
2	4	1	56	8	7	46	10	7
3	8	8.5	36	12	10.5	35	12	10.5
4	9	10.5	38	12	10.5	36	12	10.5
5	5	2.5	57	8	7	46	10	7
6	7	6	70	5	4	53	9	4.5
7	7	6	52	9	9	44	11	9
8	8	8.5	68	6	5	52	9	4.5
9	7	6	90	1	2	63	7	2.5
10	6	4	94	1	2	65	6	1
11	5	2.5	92	1	2	64	7	2.5

$\bar{X}$ for centre = 64.6

S for centre = 19.4

R between O.M. (i) and O.M. (ii) = 0.464

R between O.M. (i) and O.M. (iii) = 0.450

Significance of R.

This rank correlation coefficient has been designed so that when the two rankings are identical the rank correlation coefficient has the value + 1. When the rankings are as greatly in disagreement as possible i.e. when one ranking is exactly the reverse of the other, the rank correlation coefficient is - 1.

Tables were consulted[24] for the different College sample sizes, and the significance or otherwise of R found.

If R is significant at better than the 5% level for the sample size, it is very unlikely to have occurred by chance i.e. the O-grade band has been a good predictor of the O-1 score.

In the case of this centre, R is not highly significant.

Centre 2

Student	O-grade band	O.M. (i)	O-1 Mark	O-1 band	O.M. (ii)	O-1 Standardised Mark	Band	O.M. (iii)
1	8	7	62	7	1.5	64	7	1.5
2	6	4	15	13	14	28	13	15
3	5	2	53	9	4.5	57	8	4.5
4	9	11.5	37	12	11.5	45	10	9.5
5	10	15	35	12	11.5	43	11	12.5
6	5	2	62	7	1.5	64	7	1.5
7	9	11.5	54	9	4.5	58	8	4.5
8	5	2	43	11	9	49	10	9.5
9	9	11.5	40	11	9	47	10	9.5
10	8	7	28	13	14	38	12	14
11	9	11.5	31	13	14	40	11	12.5
12	9	11.5	54	9	4.5	58	8	4.5
13	7	5	49	10	7	54	9	7
14	9	11.5	40	11	9	47	10	9.5
15	8	7	53	9	4.5	57	8	4.5

$\overline{X}$ for centre = 43.7

S for centre = 12.8

R between O.M. (i) and O.M. (ii) = 0.332

R between O.M. (i) and O.M. (iii) = 0.303

<u>Significance of R.</u>

In the case of this centre, R is not highly significant.

<u>Centre 3</u>

Student	O-grade band	O.M. (i)	0-1 Mark	0-1 band	O.M. (ii)	0-1 Stand-ardised Mark	Band	O.M. (iii)
1	7	7	41	11	15.5	46	10	16
2	6	4	47	10	12.5	50	9	11.5
3	6	4	E	1	2.5	E	1	2.5
4	5	1.5	38	12	18	45	10	16
5	9	19	81	3	5	68	6	5.5
6	8	12	70	5	7.5	62	7	7.5
7	8	12	46	10	12.5	49	10	16
8	9	19	71	5	7.5	62	7	7.5
9	9	19	44	11	15.5	48	10	16
10	8	12	E	1	2.5	E	1	2.5
11	9	19	51	9	10	52	9	11.5
12	5	1.5	E	1	2.5	E	1	2.5
13	8	12	49	10	12.5	51	9	11.5
14	6	4	E	1	2.5	E	1	2.5
15	8	12	37	12	18	44	11	19
16	9	19	48	10	12.5	50	9	11.5

Student	O-grade band	O.M. (i)	O-1 Mark	O-1 band	O.M. (ii)	O-1 Standardised Mark	Band	O.M. (iii)
17	9	19	38	12	18	45	10	[illegible]
18	7	7	64	7	9	59	8	[illegible]
19	7	7	79	4	6	67	6	5.5
20	8	12	20	13	21	35	12	20
21	9	19	18	13	21	34	13	21.5
22	8	12	18	13	21	34	13	21.5

Note

The letter E in this and subsequent lists, indicates that the student was exempt from having to sit the relevant examination. In such cases the student has been awarded a band 1 mark.

$\bar{X}$ for centre = 47.8

S for centre = 18.7

R between O.M. (i) and O.M. (ii) = 0.320

R between O.M. (i) and O.M. (iii) = 0.356

Significance of R.

In the case of this centre, R is not highly significant.

Centre 4

Student	O-grade band	O.M. (i)	O-1 Mark	O-1 band	O.M. (ii)	O-1 Standardised Mark	Band	O.M. (iii)
1	6	3.5	43	11	5.5	50	9	4.5
2	8	7	45	10	4	52	9	4.5
3	6	3.5	60	7	1.5	62	7	2
4	4	2	62	7	1.5	64	7	2
5	7	5.5	57	8	3	60	7	2
6	7	5.5	40	11	5.5	48	10	6
7	3	1	27	13	8	38	12	8
8	10	9	28	13	8	39	12	8
9	9	8	24	13	8	36	12	8

$\bar{X}$ for centre = 42.9

S for centre = 13.7

R between O.M. (i) and O.M. (ii) = 0.388

R between O.M. (i) and O.M. (iii) = 0.400

Significance of R.

In the case of this centre, R is not highly significant.

Centre 5

Student	O-grade band	O.M. (i)	O-1 Mark	O-1 band	O.M. (ii)	O-1 Standardised Mark	Band	O.M. (iii)
1	9	39	35	12	36	40	11	35.5
2	7	21.5	13	13	40.5	26	13	42
3	7	21.5	63	7	11	57	8	11
4	9	39	59	8	17	55	8	11
5	9	39	34	13	40.5	39	12	39
6	8	31	60	7	11	56	8	11
7	7	21.5	72	5	4	63	7	4.5
8	5	5	51	9	24	50	9	21.5
9	7	21.5	57	8	17	54	9	21.5
10	7	21.5	53	9	24	51	9	21.5
11	8	31	57	8	17	54	9	21.5
12	7	21.5	46	10	28.5	47	10	28.5
13	7	21.5	67	6	7	60	7	4.5
14	4	1.5	74	5	4	64	7	4.5
15	8	31	51	9	24	50	9	21.5
16	9	39	77	4	2	66	6	2
17	5	5	33	13	40.5	39	12	39
18	6	11.5	83	3	1	70	5	1
19	5	5	52	9	24	51	9	21.5
20	8	31	59	8	17	55	8	11
21	8	31	54	9	24	52	9	21.5
22	7	21.5	52	9	24	51	9	21.5
23	6	11.5	63	7	11	57	8	11
24	9	39	42	11	32	44	11	35.5
25	8	31	64	7	11	58	8	11

Student	O-grade band	O.M. (i)	O-1 Mark	O-1 band	O.M. (ii)	O-1 Standardised Mark	Band	O.M. (iii)
26	9	39	66	6	7	59	8	11
27	6	11.5	66	6	7	59	8	11
28	6	11.5	40	11	32	43	11	33.5
29	9	39	52	9	24	51	9	21.5
30	6	11.5	64	7	11	58	8	11
31	9	39	16	13	40.5	28	13	42
32	7	21.5	40	11	32	43	11	33.5
33	5	5	31	13	40.5	37	12	39
34	7	21.5	45	10	28.5	46	10	28.5
35	7	21.5	38	12	36	42	11	33.5
36	6	11.5	71	5	4	62	7	4.5
37	6	11.5	55	8	17	52	9	21.5
38	6	11.5	56	8	17	53	9	21.5
39	8	31	40	11	32	43	11	33.5
40	4	1.5	58	8	17	54	9	21.5
41	5	5	17	13	40.5	28	13	42
42	7	21.5	40	11	32	43	11	33.5
43	9	39	35	12	36	40	11	33.5

$\bar{X}$ for centre = 51.2

S for centre = 15.9

R between O.M. (i) and O.M. (ii) = 0.137

R between O.M. (i) and O.M. (iii) = 0.099

Significance of R.

In the case of this centre, R is not at all significant.

Centre 6

Student	O-grade band	O.M. (i)	0-1 Mark	0-1 band	O.M. (ii)	0-1 Stand-ardised Mark	Band	O.M. (iii)
1	7	18	E	1	2.5	E	1	2.5
2	9	33.5	47	10	21.5	52	9	22
3	9	33.5	51	9	15	56	8	14
4	5	6.5	46	10	21.5	51	9	22
5	6	11.5	63	7	6.5	66	6	6
6	7	18	47	10	21.5	52	9	22
7	8	24.5	40	11	28	46	10	28.5
8	9	33.5	60	7	6.5	63	7	8
9	9	33.5	46	10	21.5	51	9	22
10	8	24.5	40	11	28	46	10	28.5
11	8	24.5	28	13	37	36	12	36
12	6	11.5	E	1	2.5	E	1	2.5
13	9	33.5	54	9	15	58	8	14
14	7	18	25	13	37	34	13	39
15	6	11.5	52	9	15	56	8	14
16	7	18	51	9	15	56	8	14
17	9	33.5	44	11	28	50	9	22
18	5	6.5	36	12	32.5	43	11	33
19	8	24.5	40	11	28	46	10	28.5
20	5	6.5	E	1	2.5	E	1	2.5
21	10	40	32	13	37	40	11	33
22	4	3	54	9	15	58	8	14
23	9	33.5	40	11	28	46	10	28.5

Student	O-grade band	O.M. (i)	O-1 Mark	O-1 band	O.M. (ii)	O-1 Standardised Mark	Band	O.M. (iii)
24	9	33.5	12	13	37	23	13	39
25	6	11.5	48	10	21.5	53	9	22
26	8	24.5	28	13	37	36	12	36
27	4	3	42	11	28	48	10	28.5
28	6	11.5	55	8	9.5	59	8	14
29	9	33.5	68	6	5	70	5	5
30	9	33.5	45	10	21.5	50	9	22
31	6	11.5	40	11	28	46	10	28.5
32	4	3	58	8	9.5	61	7	8
33	7	18	52	9	15	56	8	14
34	8	24.5	36	12	32.5	43	11	34
35	3	1	E	1	2.5	E	1	2.5
36	7	18	55	8	9.5	59	8	14
37	7	18	57	8	9.5	61	7	8
38	9	33.5	24	13	37	33	13	39
39	9	33.5	28	13	37	36	12	36
40	5	6.5	50	9	15	55	8	14

$\overline{X}$ for centre = 44.3

S for centre = 12.0

R between O.M. (i) and O.M. (ii) = 0.414

R between O.M. (i) and O.M. (iii) = 0.392

<u>Significance of R.</u>

0.414 is significant at better than the 1% level.

0.392 is significant at the 5% but not at the 1% level.

Centre 7

Student	O-grade band	O.M. (i)	O-1 Mark	O-1 band	O.M. (ii)	O-1 Standardised Mark	Band	O.M. (iii)
1	9	19.5	50	9	8.5	54	9	12
2	7	7	40	11	16.5	47	10	17.5
3	6	4	44	11	16.5	50	9	12
4	10	23	32	13	22.5	41	11	21.5
5	8	13	40	11	16.5	47	10	17.5
6	7	7	54	9	8.5	57	8	7
7	5	2.5	E	1	1.5	E	1	1.5
8	8	13	41	11	16.5	48	10	17.5
9	7	7	55	8	5.5	58	8	7
10	4	1	77	4	3	74	5	3
11	8	13	40	11	16.5	47	10	17.5
12	8	13	33	13	22.5	42	11	21.5
13	8	13	45	10	11.5	51	9	12
14	9	19.5	51	9	8.5	55	8	7
15	7	7	56	8	5.5	59	8	7
16	9	19.5	40	11	16.5	47	10	17.5
17	9	19.5	53	9	8.5	57	8	7
18	13	24	61	7	4	62	7	4
19	8	13	40	11	16.5	47	10	17.5
20	9	19.5	45	10	11.5	51	9	12
21	7	7	25	13	22.5	36	12	23
22	8	13	44	11	16.5	50	9	12
23	9	19.5	7	13	22.5	22	13	24
24	5	2.5	E	1	1.5	E	1	1.5

$\bar{X}$ for centre = 44.2

S for centre = 13.5

R between O.M. (i) and O.M. (ii) = 0.348

R between O.M. (i) and O.M. (iii) = 0.373

Significance of R.

In the case of this centre, R is not highly significant.

Centre 8

Student	O-grade band	O.M. (i)	O-1 Mark	O-1 band	O.M. (ii)	O-1 Standardised Mark	Band	O.M. (iii)
1	7	8	25	13	15	36	12	15
2	8	11.5	70	5	5.5	59	8	6
3	7	8	73	5	5.5	61	7	3.5
4	9	14	45	10	11.5	46	10	11.5
5	10	16	9	13	15	27	13	16
6	6	3	48	10	11.5	48	10	11.5
7	6	3	75	4	3	62	7	3.5
8	7	8	55	8	8	51	9	8
9	6	3	E	1	1	E	1	1
10	7	8	45	10	11.5	46	10	11.5
11	9	14	55	8	8	51	9	8
12	6	3	76	4	3	62	7	3.5
13	7	8	76	4	3	62	7	3.5
14	6	3	49	10	11.5	48	10	11.5
15	8	11.5	56	8	8	52	9	8
16	9	14	34	13	15	40	11	14

$\overline{X}$ for centre = 52.7

S for centre = 19.2

R between O.M. (i) and O.M. (ii) = 0.510

R between O.M. (i) and O.M. (iii) = 0.507

Significance of R.

0.510 is significant at the 5% but not at the 1% level.

0.507 is significant at the 5% but not at the 1% level.

Centre 9

Student	O-grade band	O.M. (i)	O-1 Mark	O-1 band	O.M. (ii)	O-1 Standardised Mark	Band	O.M. (iii)
1	9	22	5	13	23	36	12	24
2	9	22	12	13	23	39	12	24
3	9	22	43	11	17	52	9	16.5
4	8	16.5	58	8	12	58	8	13
5	6	10.5	62	7	11	60	7	11
6	5	5.5	E	1	4.5	E	1	4.5
7	5	5.5	81	3	9.5	68	6	9.5
8	5	5.5	E	1	4.5	E	1	4.5
9	5	5.5	E	1	4.5	E	1	4.5
10	8	16.5	E	1	4.5	E	1	4.5
11	7	13.5	40	11	17	51	9	16.5
12	9	22	53	9	13.5	56	8	13
13	3	1	E	1	4.5	E	1	4.5
14	6	10.5	25	13	23	44	11	21
15	5	5.5	E	1	4.5	E	1	4.5

Student	O-grade band	O.M. (i)	O-1 Mark	O-1 band	O.M. (ii)	O-1 Stand-ardised Mark	Band	O.M. (iii)
16	8	16.5	E	1	4.5	E	1	4.5
17	6	10.5	36	12	19	49	10	19.5
18	9	22	42	11	17	52	9	16.5
19	6	10.5	83	3	9.5	69	6	9.5
20	9	22	11	13	23	38	12	24
21	10	26	8	13	23	37	12	24
22	9	22	50	9	13.5	55	8	13
23	4	2	E	1	4.5	E	1	4.5
24	5	5.5	9	13	23	37	12	24
25	7	13.5	27	13	23	45	10	19.5
26	8	16.5	47	10	15	54	9	16.5

$\bar{X}$ for centre = 38.4

S for centre = 23.4

R between O.M. (i) and O.M. (ii) = 0.592

R between O.M. (i) and O.M. (iii) = 0.604

<u>Significance of R.</u>

0.592 is significant at the 1% level.

0.604 is significant at the 1% level.

These are the figures for the individual Colleges. Clearly there is a variation from College to College, from which one could suggest that they are not testing the same things.

However, how significant is the tie-up between O-grade performance and O-1 performance, in general?

In an attempt to assess this, the value of χ^2 was calculated[25] and its significance tested using the published tables.[26] χ^2 tests essentially whether the observed frequencies in a distribution differ significantly from the frequencies which might be expected according to some assumed hypothesis. In this case it has been assumed that there is <u>no</u> tie-up between O-grade performance and O-1 performance, and as will be seen, this is shown to be wrong.

$$\chi^2 = \sum \frac{(f_o - f_e)^2}{f_e}$$

fo is the observed frequency, and

fe is the estimated frequency if there was no tie-up between O-grade and O-1 performances.

Tables 7, 8 and 9 contain the relevant figures for 185 students.

Table 7.

Frequency Table (f_o) of O-grade bands versus 0-1 bands.

(1970 entrants)

O-grade band \ 0-1 band	4	5	6	7	8	9	10	> 11	Total
4	1	0	0	3	1	1	2	0	8
5	0	0	1	2	2	4	2	5	16
6	0	1	3	5	4	6	4	3	26
7	0	0	1	7	8	8	7	8	39
8	0	0	0	2	7	10	8	10	37
9	0	1	2	2	10	12	9	17	53
10	0	0	0	0	0	0	0	6	6
Totals	1	2	7	21	32	41	32	49	185

Table 8.

Observed frequencies (f_0)

(expressed as %)

0-1 band / 0-grade band	4	5	6	7	8	9	10	> 11	Total
4	12.5%	-	-	37.5	12.5	12.5	25	-	100%
5	-	-	6.25	12.5	12.5	25	12.5	31.25	100%
6	-	3.85	11.54	19.23	15.38	23.08	15.38	11.54	100%
7	-	-	2.56	17.95	20.51	20.51	17.95	20.51	99.99%
8	-	-	-	5.41	18.92	27.03	21.62	27.03	100.01%
9	-	1.89	3.81	3.81	18.87	22.64	16.98	32.00	100%
10	-	-	-	-	-	-	-	100%	100%
Totals	12.5	5.74	24.16	96.40	98.68	130.76	109.43	222.33	700%

Table 9.

Estimated frequencies (f_e)

O-grade band \ O-1 band	4	5	6	7	8	9	10	> 11
4	1.79 64.08	0.82 0.82	3.45 3.45	13.77 40.89	14.10 0.18	18.68 2.04	15.63 5.62	31.76 31.76
5	1.79 1.79	0.82 0.82	3.45 2.27	13.77 0.12	14.10 0.18	18.68 2.14	15.63 0.63	31.76 0.01
6	1.79 1.79	0.82 11.20	3.45 18.97	13.77 2.16	14.10 0.12	18.68 1.04	15.63 0.00	31.76 12.87
7	1.79 1.79	0.82 0.82	3.45 0.23	13.77 1.27	14.10 2.91	18.68 0.18	15.63 0.34	31.76 3.98
8	1.79 1.79	0.82 0.82	3.45 3.45	13.77 5.08	14.10 1.65	18.68 3.73	15.63 2.30	31.76 0.70

Table 9. (Cont'd).

O-grade band \ O-1 band	4	5	6	7	8	9	10	> 11
9	1.79 1.79	0.82 1.40	3.45 0.04	13.77 7.20	14.10 1.61	18.68 0.84	15.63 0.12	31.76 0.00
10	1.79 1.79	0.82 0.82	3.45 3.45	13.77 13.77	14.10 14.10	18.68 18.68	15.63 15.63	31.76 146.62

	x
y	

$$x = f_e$$

$$y = \frac{(f_o - f_e)^2}{f_e}$$

Calculation gives

$$\chi^2 = 463.85 \text{ for 42 degrees of freedom.}$$

From tables, this figure is highly significant (at better than the 1% level) and means that the discrepancy between observed and expected frequencies did not arise by chance i.e. O-grade performance provides a fairly good prediction of O-1 performance taken over all the centres together.

Correlation between performance in O-grade, O-1 and O-2 chemistry.

The marks of students who had completed these 3 courses by August 1972 were obtained, and 3 orders of merit compiled:-

(i) O.M. (i) depended upon the band mark obtained at O-grade

(ii) O.M. (ii) depended upon the standardised O-1 mark, expressed as a band mark

(iii) The total mark obtained by each student at the O-2 stage, in physical, organic and inorganic chemistry was calculated. These marks were then standardised to a mean of 50 and a standard deviation of 10 before being expressed as a band mark. O.M. (iii) depended upon this mark.

The results are shown overleaf.

Student	O-grade band	O.M. (i)	O-1 Stand-ardised Mark	Band	O.M. (ii)	Total O-2 Mark	O-2 Stand-ardised Mark	Band	O.M. (iii)
1	9	61.5	47	10	63.5	51	36	12	64
2	4	4.5	46	10	63.5	102	47	10	38.5
3	7	38	44	11	69	87	44	11	52
4	8	49	52	9	49.5	73	41	11	52
5	7	38	63	7	24	198	67	6	5.5
6	8	49	63	7	24	132	53	9	27.5
7	5	11.5	63	7	24	168	60	7	11
8	9	61.5	57	8	35.5	82	43	11	52
9	9	61.5	57	8	35.5	166	60	7	11
10	6	23.5	E	1	6.5	131	53	9	27.5
11	8	49	62	7	24	105	47	10	38.5
12	9	61.5	52	9	49.5	71	40	11	52
13	5	11.5	E	1	6.5	152	57	8	18
14	7	38	67	6	16	197	66	6	5.5
15	8	49	52	9	49.5	56	37	12	64
16	6	23.5	62	7	24	79	42	11	52
17	7	38	63	7	24	129	52	9	27.5
18	7	38	51	9	49.5	156	58	8	18
19	7	38	60	7	24	195	66	6	5.5
20	4	4.5	64	7	24	186	64	7	11
21	6	23.5	70	5	13.5	226	72	5	1.5
22	8	49	52	9	49.5	137	54	9	27.5
23	7	38	51	9	49.5	126	52	9	27.5
24	9	61.5	59	8	35.5	101	46	10	38.5
25	6	23.5	59	8	35.5	183	64	7	11

Student	O-grade band	O.M. (i)	O-1 Standardised Mark	Band	O.M. (ii)	Total O-2 Mark	O-2 Standardised Mark	Band	O.M. (iii)
26	9	61.5	51	9	49.5	109	48	10	38.5
27	6	23.5	58	8	35.5	105	47	10	38.5
28	7	38	46	10	63.5	74	41	11	52
29	6	23.5	62	7	24	199	67	6	5.5
30	6	23.5	52	9	49.5	117	50	9	27.5
31	6	23.5	53	9	49.5	102	47	10	38.5
32	4	4.5	54	9	49.5	102	47	10	38.5
33	7	38	E	1	6.5	128	52	9	27.5
34	9	61.5	56	8	35.5	106	48	10	38.5
35	5	11.5	51	9	49.5	137	54	9	27.5
36	6	23.5	66	6	16	89	44	11	52
37	7	38	52	9	49.5	56	37	12	64
38	9	61.5	63	7	24	83	43	11	52
39	8	49	51	9	49.5	47	35	12	64
40	6	23.5	E	1	6.5	112	49	10	38.5
41	9	61.5	50	9	49.5	85	43	11	52
42	5	11.5	E	1	6.5	121	51	9	27.5
43	4	4.5	58	8	35.5	208	69	6	5.5
44	9	61.5	46	10	63.5	117	50	9	27.5
45	6	23.5	53	9	49.5	84	43	11	52
46	9	61.5	70	5	13.5	151	57	8	18
47	4	4.5	61	7	24	103	47	10	38.5
48	3	1	E	1	6.5	110	48	10	38.5
49	6	23.5	50	9	49.5	91	44	11	52
50	8	49	47	10	63.5	34	33	13	69

Student	O-grade band	O.M. (i)	O-1 Standardised Mark	Band	O.M. (ii)	Total O-2 Mark	O-2 Standardised Mark	Band	O.M. (iii)
51	5	11.5	E	1	6.5	140	55	8	18
52	9	61.5	57	8	35.5	58	38	12	64
53	8	49	47	10	63.5	48	35	12	64
54	9	61.5	46	10	63.5	61	38	12	64
55	6	23.5	48	10	63.5	102	47	10	38.5
56	6	23.5	62	7	24	49	36	12	64
57	6	23.5	E	1	6.5	143	55	8	18
58	7	38	46	10	63.5	69	40	11	52
59	9	61.5	51	9	49.5	77	41	11	52
60	7	38	62	7	24	176	62	7	11
61	6	23.5	48	10	63.5	61	38	12	64
62	5	11.5	68	6	16	149	56	8	18
63	5	11.5	E	1	6.5	142	55	8	18
64	7	38	51	9	49.5	141	55	8	18
65	9	61.5	56	8	35.5	88	44	11	52
66	5	11.5	E	1	6.5	163	59	8	18
67	8	49	E	1	6.5	222	72	5	1.5
68	9	61.5	55	8	35.5	74	41	11	52
69	4	4.5	E	1	6.5	210	69	6	5.5

Mean O-2 Total Mark = 117.9

Standard Deviation = 48.1

R between O.M. (i) and O.M. (iii) = 0.421

R between O.M. (ii) and O.M. (iii) = 0.587

Significance of R.

Both correlation coefficients are significant at the 1% level.

Of the 69 candidates whose performances were obtained in O-grade, O-1 and O-2 chemistry, 50% actually failed the national examination at the end of the O-2 year. Only 30% passed, the remaining 20% having to resit at least one part of the examination.

B. The 1971 Entrants.

Correlation between performances in O-grade and O-1 chemistry.

Once again the performance of as many candidates as possible in the S.C.E. O-grade examination in alternative chemistry was obtained. This took the form of a band mark as before. The students in each College were placed in an order of merit $\overset{O.M.}{(i)}$ depending upon these results.

The mark of each student in O-1 chemistry was obtained. The mean $(\overline{X})$ and the standard deviation (S) for each College was found, and each mark standardised to a mean of 50 and a standard deviation of 10. This standardised mark was converted to a band mark (Table 6) from which a second order of merit $\overset{O.M.}{(ii)}$ was compiled for each College. As before, students who had been given exemption from the examination, were placed in band 1.

The Spearman Rank Correlation Coefficient[23] (R) between the 2 orders of merit was calculated.

Because of the similarity between the 2 rank correlation coefficients which had been calculated for each College, in respect of the 1970 entrants, it was felt to be unnecessary to obtain a rank correlation coefficient between the O-grade band order of merit $\overset{O.M.}{(i)}$ and an order of merit based on the raw score of each student in each of the 9 Colleges.

Results for each of the 9 examination centres follow.

Centre 1

Student	O-grade band	O.M. (i)	O-1 Mark	O-1 Stand-ardised Mark	Band	O.M. (ii)
1	7	2.5	84	61	7	1.5
2	6	1	85	62	7	1.5
3	8	4.5	57	41	11	5
4	7	2.5	66	47	10	4
5	9	6	74	54	9	3
6	8	4.5	50	35	12	6

$\bar{X}$ for centre = 69.3

S for centre = 13.0

R between O.M. (i) and O.M. (ii) = 0.571

Significance of R.

R is not significant. The sample is too small.

Centre 2

Student	O-grade band	O.M. (i)	O-1 Mark	O-1 Stand-ardised Mark	Band	O.M. (ii)
1	7	2.5	72	67	6	1
2	5	1	54	55	8	2
3	9	5.5	51	54	9	3
4	9	5.5	41	47	10	4
5	8	3.5	22	36	12	6
6	8	3.5	31	41	11	5

$\overline{X}$ for centre = 45.2

S for centre = 16.2

R between O.M. (i) and O.M. (ii) = 0.421

Significance of R.

R is not significant. The sample is too small.

Centre 3

Student	O-grade band	O.M. (i)	O-1 Mark	O-1 Standardised Mark	Band	O.M. (ii)
1	5	2.5	E	E	1	1.5
2	7	8	62	54	8	6
3	5	2.5	41	43	11	10.5
4	9	12.5	67	57	8	6
5	6	5	21	32	13	13
6	7	8	E	E	1	1.5
7	8	10.5	73	60	7	4
8	9	12.5	40	42	11	10.5
9	3	1	65	56	8	6
10	6	5	81	65	6	3
11	7	8	28	36	12	12
12	6	5	59	53	9	8.5
13	8	10.5	57	52	9	8.5

$\overline{X}$ for centre = 54

S for centre = 18.1

R between O.M. (i) and O.M. (ii) = 0.107

Significance of R.

R is not highly significant.

Centre 4

Student	O-grade band	O.M. (i)	O-1 Mark	O-1 Standardised Mark	Band	O.M. (ii)
1	8	11	50	51	9	12
2	9	16	19	35	12	17.5
3	9	16	29	40	11	15.5
4	5	3.5	50	51	9	12
5	8	11	32	42	11	15.5
6	8	11	85	68	6	7.5
7	8	11	78	65	6	7.5
8	8	11	E	E	1	3.5
9	4	1	E	E	1	3.5
10	5	3.5	E	E	1	3.5
11	9	16	20	36	12	17.5
12	6	6.5	E	E	1	3.5
13	5	3.5	59	55	8	9.5
14	12	18	55	53	9	12
15	8	11	47	49	10	14
16	8	11	E	E	1	3.5
17	5	3.5	E	E	1	3.5
18	6	6.5	60	56	8	9.5

$\bar{X}$ for centre = 48.7

S for centre = 20.0

R between O.M. (i) and O.M. (ii) = 0.649

Significance of R.

R is significant at better than the 1% levels.

Centre 5

Student	O-grade band	O.M. (i)	O-1 Mark	O-1 Standardised Mark	Band	O.M. (ii)
1	9	16	34	38	12	21
2	8	8.5	40	43	11	19.5
3	4	1	47	49	10	16.5
4	9	16	49	51	9	11
5	9	16	58	59	8	5
6	5	2.5	56	57	8	5
7	9	16	62	62	7	2
8	9	16	48	50	9	11
9	7	5.5	46	48	10	16.5
10	10	22	36	40	11	19.5
11	11	23	53	54	9	11
12	9	16	50	52	9	11
13	9	16	52	54	9	11
14	8	8.5	56	57	8	5
15	5	2.5	43	46	10	16.5
16	7	5.5	73	71	5	1
17	8	8.5	45	48	10	16.5
18	9	16	56	57	8	5
19	6	4	49	51	9	11
20	9	16	55	56	8	5
21	9	16	23	29	13	22.5
22	8	8.5	52	54	9	11
23	9	16	17	24	13	22.5

$\overline{X}$ for centre = 47.8

S for centre = 11.9

R between O.M. (i) and O.M. (ii) = 0.133

<u>Significance of R.</u>

R is not highly significant.

<u>Centre 6.</u>

Student	O-grade band	O.M. (i)	0-1 Mark	0-1 Standardised Mark	Band	O.M. (ii)
1	9	11.5	54	55	8	3.5
2	6	4.5	72	70	5	1
3	6	4.5	56	57	8	3.5
4	6	4.5	45	48	10	9.5
5	6	4.5	52	53	9	6.5
6	9	11.5	60	60	7	2
7	9	11.5	48	50	9	6.5
8	9	11.5	40	43	11	12
9	9	11.5	40	43	11	12
10	9	11.5	17	24	13	14
11	6	4.5	44	47	10	9.5
12	6	4.5	52	53	9	6.5
13	8	8	41	44	11	12
14	5	1	51	52	9	6.5

$\overline{X}$ for centre = 48

S for centre = 12.0

R between O.M. (i) and O.M. (ii) = 0.333

<u>Significance of R.</u>

R is not highly significant.

Centre 7.

Student	O-grade band	O.M. (i)	O-1 Mark	O-1 Standardised Mark	Band	O.M. (ii)
1	5	2.5	34	35	12	20
2	9	16.5	42	40	11	17.5
3	9	16.5	62	53	9	11
4	9	16.5	78	63	7	4.5
5	9	16.5	50	45	10	14.5
6	9	16.5	32	34	13	22
7	4	1	53	47	10	14.5
8	7	6.5	65	55	8	8
9	7	6.5	77	62	7	4.5
10	8	9.5	52	46	10	14.5
11	7	6.5	85	68	6	2
12	9	16.5	78	63	7	4.5
13	9	16.5	65	55	8	8
14	9	16.5	80	64	7	4.5
15	9	16.5	57	50	9	11
16	9	16.5	38	37	12	20
17	5	2.5	E	E	1	1
18	6	4	40	39	12	20
19	7	6.5	44	41	11	17.5
20	8	9.5	54	48	10	14.5
21	9	16.5	58	50	9	11
22	9	16.5	65	55	8	8

$\overline{X}$ for centre = 57.6

S for centre = 15.6

R between O.M. (i) and O.M. (ii) = 0.063

Significance of R.

R is not highly significant.

Centre 8.

Student	O-grade band	O.M. (i)	0-1 Mark	0-1 Standardised Mark	Band	O.M. (ii)
1	9	14.5	40	45	10	14
2	9	14.5	61	57	8	9.5
3	7	9.5	E	E	1	3.5
4	6	7.5	E	E	1	3.5
5	4	1	E	E	1	3.5
6	5	4	E	E	1	3.5
7	7	9.5	E	E	1	3.5
8	8	11.5	22	34	13	16.5
9	9	14.5	30	39	12	15
10	5	4	67	60	7	7
11	5	4	65	59	8	9.5
12	6	7.5	54	53	9	12.5
13	5	4	E	E	1	3.5
14	5	4	64	59	8	9.5
15	9	14.5	55	53	9	12.5
16	10	17	63	58	8	9.5
17	8	11.5	20	33	13	16.5

$\overline{X}$ for centre = 49.2

S for centre = 17.1

R between O.M. (i) and O.M. (ii) = 0.602

Significance of R.

R is significant at 5% level.

Centre 9.

Student	O-grade band	O.M. (i)	O-1 Mark	O-1 Standardised Mark	Band	O.M. (ii)
1	7	19	46	44	11	29.5
2	6	12.5	49	46	10	22
3	9	32	35	38	12	35.5
4	4	4	73	60	7	5.5
5	9	32	70	58	8	12
6	6	12.5	80	64	7	5.5
7	5	8	54	49	10	22
8	9	32	52	48	10	22
9	6	12.5	72	59	8	12
10	5	8	40	41	11	29.5
11	4	4	66	56	8	12
12	5	8	81	64	7	5.5
13	7	19	54	49	10	22
14	11	39	27	34	13	38
15	9	32	22	31	13	38
16	3	1	77	62	7	5.5
17	10	37.5	62	53	9	17.5
18	7	19	68	57	8	12
19	8	25	40	41	11	29.5
20	6	12.5	70	58	8	12
21	9	32	63	54	9	17.5
22	7	19	42	42	11	29.5

Student	O-grade band	O.M. (i)	O-1 Mark	O-1 Standardised Mark	Band	O.M. (ii)
23	4	4	42	42	11	29.5
24	8	25	52	48	10	22
25	4	4	89	69	6	1.5
26	10	37.5	26	33	13	38
27	9	32	41	42	11	29.5
28	7	19	40	41	11	29.5
29	7	19	33	37	12	35.5
30	8	25	38	40	11	29.5
31	6	12.5	70	58	8	12
32	7	19	73	60	7	5.5
33	9	32	58	51	9	17.5
34	9	32	42	42	11	29.5
35	4	4	89	69	6	1.5
36	8	25	73	60	7	5.5
37	6	12.5	71	59	8	12
38	8	25	38	40	11	29.5
39	8	25	58	51	9	17.5

$\overline{X}$ for centre = 55.8

S for centre = 17.8

R between O.M. (i) and O.M. (ii) = 0.566

<u>Significance of R.</u>

R is significant at the 1% level.

The general tie-up between O-grade performance and O-1 performance for the 1971 entrants was calculated in the same way as for the 1970 entrants. Tables 10, 11 and 12 contain the relevant figures for 138 students.

Table 10.

Frequency Table (f_o) of O-grade bands versus O-1 bands.

(1971 entrants)

O-grade band \ O-1 band	4	5	6	7	8	9	10	> 11	Total
4	0	0	2	1	1	0	2	1	7
5	0	0	0	2	5	2	2	3	14
6	0	1	1	2	6	5	3	2	20
7	0	1	2	3	3	0	3	6	18
8	0	0	2	2	1	4	5	12	26
9	0	0	0	5	9	13	4	18	49
10	0	0	0	0	1	1	0	2	4
Totals	0	2	7	15	26	25	19	44	138

Table 11.

Observed Frequencies (f_o)

(expressed as %)

O-1 band / O-grade band	4	5	6	7	8	9	10	> 11	Total
4	0	0	28.57	14.29	14.29	0	28.57	14.29	100.01%
5	0	0	0	14.29	35.71	14.29	14.29	21.43	100.01%
6	0	5	5	10	30	25	15	10	100%
7	0	5.55	11.11	16.67	16.67	0	16.67	33.33	100%
8	0	0	7.69	7.69	3.85	15.38	19.23	46.15	99.99%
9	0	0	0	10.20	18.37	26.53	8.16	36.73	99.99%
10	0	0	0	0	25	25	0	50	100%
Totals	0	10.55	52.37	73.14	143.89	106.20	101.92	211.93	700%

Table 12.

Estimated frequencies (f_e)

O-grade band \ 0-1 band	4	5	6	7	8	9	10	> 11
4	0 0	1.51 1.51	7.48 59.46	10.45 1.41	20.56 1.91	15.17 15.17	14.56 13.48	30.28 8.44
5	0 0	1.51 1.51	7.48 7.48	10.45 1.41	20.56 11.16	15.17 0.05	14.56 0.01	30.28 2.59
6	0 0	1.51 8.07	7.48 0.82	10.45 0.02	20.56 4.33	15.17 6.37	14.56 0.01	30.28 13.58
7	0 0	1.51 10.81	7.48 1.76	10.45 3.70	20.56 0.74	15.17 15.17	14.56 0.31	30.28 0.31
8	0 0	1.51 1.51	7.48 0.01	10.45 0.73	20.56 13.50	15.17 0.00	14.56 1.50	30.28 0.32

Table 12.

Estimated frequencies (f_e) (Cont'd).

O-grade band \ O-1 band	4	5	6	7	8	9	10	> 11
9	0 0	1.51 1.51	7.48 7.48	10.45 0.01	20.56 0.23	15.17 8.51	14.56 2.81	30.28 1.37
10	0 0	1.51 1.51	7.48 7.48	10.45 10.45	20.56 0.96	15.17 6.37	14.56 14.56	30.28 12.84

	x
y	

$x = f_e$

$$y = \frac{(f_o - f_e)^2}{f_e}$$

$$\chi^2 = 293.33$$

for 42 degrees of freedom

Figure is significant at better than the 1% level.

The value of χ^2 again indicates that overall, O-grade performance provides a fairly good prediction of O-1 performance.

It seems that O-grade chemistry is a fairly good overall predictor of performance, although in this respect much is asked of it. It is used as an entrance to

an H-grade course

University

other forms of tertiary education

banking

H.M. Forces

the Civil Service.

But it is clear that there is a wide variation between Colleges at O-1 stage particularly. One wonders if each College is examining the same objectives at this stage. It seems doubtful if they are. Can the Colleges, therefore, criticise the O-grade and the students which it produces? Should the Colleges adapt more, to cope with present day O-grade students?

If O-grade predicts well for some Colleges and not for others, a student passed at one College might well fail in another. Thus his entry into O-2 depends upon his choice of College and his chances of success at O-2 are bound up with his College choice.

If O-1 exams are to be set internally to act as a filter for O-2, they must be externally moderated and scores standardised.

CHAPTER 5.

Conclusions, Recommendations and Future Scope.

It will have been noted in the foregoing that much work is being undertaken at present to evaluate the new Scottish school chemistry syllabuses, and surely nothing but good can come of this. But out of the work covered in this report, some points seem clear.

The majority of pupils experience a first liking for science during S1 and S2 and have quite clear reasons for choosing chemistry in S3. A good teacher at school and an interesting course clearly influence their interest in the subject.

Reference was made to Curriculum Papers 7[12] previously, and to how important its effect on post S2 chemistry will be. It is, therefore, disquieting to read that one researcher has shown that this Scottish syllabus can fulfil objectives directly opposite to those originally intended by the curriculum planners.[28]

There are clear areas of difficulty in the O-grade course and it is hoped that both teachers and curriculum planners can benefit from the results detailed in chapter 2. The former must have the areas of difficulty brought to their notice and might be prepared to tackle the work in a different way, at a different rate, or at a different point in the course. The latter would want to bear the views of the students in mind. because there are anxieties about present trends in elementary chemical education being expressed. A recent issue of "Chemistry in Britain" highlights some of the problems,[29] and it is hoped that in Scotland we will never have the following comment made about our school pupils:-

"The background in chemistry of entering students (into Colleges and Universities) who have completed the course in High School chemistry is increasingly superficial. In large part, this appears to be the result of the 'modern' courses which have been developed for use in the High Schools. These courses have been a tremendous stimulus for the top 10 or 20 per cent of High School teachers. For the bottom 50% they have been a disaster, since these teachers are not well equipped to present the material and for the most part their students do not have the background to assimilate it. The result is that a very large number of students now enter College with some familiarity with the terminology in one or more areas of advanced chemistry, but no real understanding of them. These students have not even mastered the elementary descriptive chemistry which formerly could be expected of High School graduates."[30]

The majority of the students seem satisfied, on the whole,with their O-1 course, although not stimulated by it. The pace was faster, and about half the students felt that the entrance qualification demanded was inadequate. Whatever will happen to the standard of the O-grade examination following the system of grading to be introduced in 1973, despite the assurances of the S.C.E. Examination Board, is a matter for conjecture, but one experienced Head of Department in one of the F.E. Colleges which cooperated in this work,feels that even at the present time "The majority of students entering National Certificate courses are of a very poor calibre compared with a few years ago. Few students seem to show any great drive, some do not seem to mind whether or not they fail, and almost all are quite happy to scrape a pass."

While the O-1 students reacted favourably to the success of the suggested objectives concerning practical work, from their subsequent comments it was clear that they had problems,and one wonders if the current presentation of the practical work is suitable for O-grade students taught at school from the new syllabuses.

It is unfortunate that so many of the important areas of difficulty at O-grade are not taught in the O-1 course. Perhaps this latter course could be brought more into line with the current O-grade course?

Sufficient comment has been made in chapter 3 concerning the views of the lecturers, who clearly are unhappy about many points - perhaps sometimes as a result of a misunderstanding. Certainly there should be more contact between teachers and lecturers. It is interesting to read that in a questionnaire sent to Colleges of F.E. by H.M.I. Dr. J. Stark, covering S.C.E. H-grade chemistry,[31] one of the questions asked was:-

"Do you have close contacts with the teachers of H-grade chemistry in neighbouring Secondary Schools?"

Responses were,	Yes	5
	No	13
	Some contact	3

Someone must take the initiative in establishing these contacts.

O-grade chemistry is a good predictor of subsequent performance in O-1, and it seems to be a good guide for O-2, but O-1 is not such a good predictor of O-2 performance. One wonders why this is so. This may be caused by the wide variations between colleges and the process of internal examination at O-1 stage.

It has not been possible in this work to cover every related aspect of interest, and inevitably one piece of research leads to another avenue which could benefit from study. It is suggested that any further work should centre round some of the following areas of interest.

1. An evaluation of Curriculum Papers 7.
2. A more exhaustive investigation into the difficulties in the practical work of O-1 courses.
3. The variations in the O-1 course between different colleges.
4. An attempt to discover why so many students pass the O-1 stage but

fail in O-2.

5. Ways in which the O-grade and O-1 syllabuses can be brought more into line.

6. Work to find how the "new course" students are faring in industry, and to obtain the views of all kinds of employers on what constitutes the "ideal" course e.g. how much general chemistry, how much technique etc.

7. A study of the relationship of the philosophy and emphasis of O-1 and O-2 courses compared with that of O-grade, by examination of S.A.N. C.A.D. syllabuses and examination papers.

8. A critical study of such City and Guilds courses as course 315 - Chemistry Technicians' Course, and course 119 - Technicians.

That tertiary education is lagging in its attempts to adjust to the new attitudes, approaches and syllabuses at the secondary level, is a cause for concern in many places. The first of two letters in a recent issue of "Chemistry in Britain"[32] puts this feeling very clearly. Such investigations at the tertiary stage as that carried out by J.H.Straiton[33] shed much light on at least some of the problems, and it may be that such a detailed study of both O-1 and O-2 chemistry courses would be beneficial to students, lecturers and industry.

The situation concerning F.E. courses in Scotland in the Technician band, will change when the Hudson Report,[33] the Scottish counterpart of the Haslegrove Report,[7] is implemented. The present National Certificate and National Diploma Courses will be replaced by a new generation of courses provided under the aegis of S.C.O.T.E.C. (Scottish Technician Education Council) a body which will succeed S.A.N.C.A.D. This development is awaited with interest.

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