An appraisal of National in metallurgy on Tees-side

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An Appraisal of
National Certificate Courses in Metallurgy
on Tees-side
1957 - 1963

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INTRODUCTION

In the four years 1957-61 it was observed at the Cleveland Technical College, Redcar, a college having its foundation in 1957, that a somewhat disturbing trend was taking place in the relative quality of entrants to Ordinary National Certificate in metallurgy compared with that in chemistry. Of the chemistry entrants 75% had GCE '0' level passes in four or more subjects as compared with 30% of the metallurgical entrants. At the other end of the scale, only 20% of the chemistry entrants had no '0' level passes in contrast to the 64% in the case of metallurgy. In the light of these figures and the advent of the White Paper "Better Opportunities in Technical Education"[1] an examination of National Certificate courses in metallurgy on Tees-side was considered worthy of investigation.

In August 1961 Metallurgia published an article on Metallurgical Education (Appendix I) and its place in a locality such as Cleveland. It is significant that two years later a Technician course was to be developed to meet the needs of not-so academic students.

Although the period of investigation is concerned with the College years 1957-63, the ramifications of current thought has its roots in the history of metallurgical education and it is relevant therefore to devote a chapter to the work of the City and Guilds of London Institute and the evolution of the National Certificate through their schemes.

Five colleges have been involved in the investigation - Constantine, Longlands, Cleveland, Stockton and West Hartlepools and the complexity of administering a scheme in which four out of the five colleges contribute to p art only of the course will be a factor for examination.

From statistical information where available, from the questionnaire and interviews with students some of the problems will be examined. It is pertinent to say that throughout the investigation and since the essay is based on source information, material has been most difficult to acquire and in some cases impossible to obtain.

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CONTENTS

Chapter 1

The Development of National Certificate courses in Metallurgy through the City and Guilds of London Institute.

Technical examinations were introduced by the Royal Society of Arts in 1870. By 1881, the City and Guilds of London Institute, founded in 1876, had become responsible for the Steel Manufacture Course and had renamed the subject Iron and Steel Manufacture. This title held until 1933. The terms of reference for this subject were "To encourage special attention to those processes of iron and steel manufacture which would be most suitable for the respective districts". The syllabus was divided into two parts and in order to pass in the "First-Class" candidates were expected to answer satisfactorily questions in both Iron Manufacture and Steel Manufacture. The examination could be taken at one of three levels, Grade I, Grade II and Final. Candidates for the final examination were expected to study additional topics to those included in Grades I and II but were permitted to select their questions from one section only or from both Iron and Steel.

TABLE I[2]

		No. of Candidates Entered	
		1929	1930
Iron and Steel Manufacture	I	-	-
	II	-	-
	Final	61	71

In 1930 and following upon an examination of the number of entries at each level (TABLE I) it was resolved that syllabuses be reviewed and that students be recommended to take a group course certificate in which the fundamental sciences were included. The philosophy underlying this recommendation was to encourage students to work for a Full Technological Certificate. It was resolved also to draw up syllabuses for a five year study period and which involved attendances on three evenings per week. By this time it was regarded that an elementary knowledge of chemistry and physics were required although

Professor Desch[3] drew attention to the problems associated with the overloading of syllabuses. Even in the present context the breadth and depth of syllabus content remains one of great issue. Nevertheless, the Iron and Steel Federation, through its accent on organised training, was able to convince employers of the need to turn away from "evening only" study and to support "day-release".

In 1931 Principal Murray, Constantine Technical College, became a member of the Advisory Committee for metallurgy and one of his early pronouncements[4] was on the need to stress the importance of the economics of metallurgical processes. This is an aspect of metallurgical education that even in modern teaching tends to be overlooked or dealt with in far too cursory a manner and yet how purposeful this could be made in a department of Complementary Studies with the accent on real living and not on obscure literature.

It is significant that, in the early days of the preparation of draft syllabuses many of the arguments were typical of our own present day concern for educational content. The need for detailed syllabuses for staff and students, the assistance given to the external candidate, the lack of practical content, the postponement of specialisation and the length and the number of examinations were some of the factors raised. The strength of feeling was such that "votes would be taken" and "resignations offered" but never accepted[5].

In 1933 the Board of Education after consultation with the City and Guilds of London Institute, and with the Union of the Lancashire and Cheshire Institutes (the oldest regional examining union and founded in 1839 as the Manchester District Association of Literary and Scientific Institutes), the Northern Counties Technical Examination Council, the East Midlands Education Union and the Union of Education Institutes, published A.M.106 (3rd May, 1933). The essence of the memorandum and its appendix (Appendix II) was to inform Local Authorities for Higher Education that the City and Guilds of London Institute were required to seek from the Board of Education approval to conduct any intermediate examination but that once approval had been given the examination may be held throughout the whole Country. Discretionary powers to enter candidates for the Institute's examination by Authority members of any of the four Unions were given to the Chief Education Officer of the Local Education Authority concerned. This document which has been in operation for more than thirty years is often referred to as the "Concordat". Until the early 1920's, there was little formal contact between the four Unions and the City and Guilds but a new examination policy emanating from the Board of Education brought them together. The new policy had profound effect upon technical education; it was to lead to the development of National Certificate schemes.

The growth of technical examinations in post World War II years required the re-appraisal of the Concordat. The three parties concerned - the Ministry, the Institute and the Unions - while affirming continued adherence to the principles involved, agreed, in 1955, that new machinery for consultation was required. To meet this need a Standing Committee was formed to deal with matters of common interest and to ensure that both National and Regional systems of examinations made their maximum contribution to the technical education of the Country.

During this time the syllabuses and schemes of work of the Institute and Examining Unions, in courses governed by the Concordat, have been so co-ordinated that each could retain its own individuality and this has required even closer co-operation between the parties concerned.

In terms of metallurgical courses it became necessary to revise schemes of work and to seek approval for the intermediate examination. Approval was given on 28th July, 1933 and the intermediate examination was held in 1934.

In announcing their decision, the Institute's Advisory Committee stated that they had drawn up a suggested curriculum for the guidance of colleges holding part-time courses for "those actively engaged in or associated with the metallurgical and allied industries". It was expected that examinations in the course other than the Intermediate and Final Examination of the Institute would be held by, or on behalf of, the Governing Authority of the Technical Institute concerned.

Subjects in the course were as follows:

1st year	Inorganic Chemistry
	Physics
	Mathematics
2nd year	General Metallurgy Inter. I
	Inorganic Chemistry
	Physics
3rd year	General Metallurgy Inter. II
	Engineering Drawing
	Chemistry or Physics or
	Mathematics or Descriptive
	Engineering
4th and 5th year	Manufacture of Iron
	Manufacture of Steel
	Physical Metallurgy.

Appendix III shows the syllabus content of the Intermediate Metallurgy course, the Final Iron and Steel course and the Physical Metallurgy course for session 1933-34.

The results of the examinations in the first year, were, to say the least, disastrous. It was necessary to ask the Advisory Committee to give some consideration to the matter before the results were definitely fixed and issued. A letter to the Committee from Professor Andrew read"------ with the application of the provision in the regulations that failure in one paper carries with it failure in the examination as a whole, the percentage failure in the Final Iron and Steel examination will be very high under the tentative results so far adjusted. In the circumstances therefore we think it necessary to ask the Advisory Committee to give some consideration to the matter before results are issued". The results are shown in TABLE II[6].

TABLE II

Grade	No. Entered	% Failure
Intermediate	48	48
Final Iron and Steel	51	92
Physical Metallurgy	66	75

The final results under strict application of the regulations that failure in one Paper carries with it failure in the examination as a whole and on the basis of a 1st Class pass of 66% and a 2nd Class pass of 50% of the total marks were:

No. of Candidates	Pass 1st	Pass 2nd	Fail	% Fail
51	1	3	47	92

In terms of contemporary thought with the need for careful selection and the Government White Paper (Command 9703) [7] definition of technologist, technician and craftsman, it is pertinent to examine the occupations of the candidates taking this examination. These are set out in TABLE III.[8]

TABLE III

FINAL EXAMINATION

Occupation	Age									Results		
	18	19	20	21	22	23	27	31	36	1st	2nd	F
Welder				1								1
Fitter					1							1
Steelworker	1	5	2	1		1					1	9
Met. Asst.	1	2		2			1					6
Chemist	3	4	3	3	2	5		1			1	20
Lab. Asst.	2				1						1	2
Analyst				2								2
Asst. Sampler				1		1						2
" Melting Shop					1							1
Machinist						1						1
Assayer									1			1
Labourer								1				1
Student		1								1		
	7	12	5	10	5	8	1	2	1	1	3	47

It is significant that in examining the poor results no consideration was given to selection, previous attainment or application of the study area.

If failure rate alone was to be considered a criterion, then lack of selection was greatest in those occupations where one would have expected better results, namely among chemists, laboratory assistants and metallurgical assistants, and indeed where basic scientific training and thought was considered a fundamental for the industry. It is apposite to note that seventeen out of fifty-one entrants would not have been considered suitable from a job specification point-of-view to be preparing for these examinations. Another disturbing trend which, at the time, seemed to be accepted without comment was the fact that twenty-seven out of a possible fifty-one candidates were twenty-one years or more.

Although the results in the Intermediate examination (48% pass) were better than the Final results, TABLE IV[9] shows the same absence of selection.

TABLE IV[9]

INTERMEDIATE EXAMINATION

Occupation	Age										Results		
	17	18	19	20	21	22	23	27	31	36	1st	2nd	F
Tinsmith				1								1	
Eng. App.			2		1		1						4
Chemist	1	3	7	4	1		1				7	3	7
Lab. Asst.		2	3	1							2	4	
Asst. Met.					1								1
Draughtsman	1												1
Clerk				2							1	1	
Steel Melter							1	1				2	
Mixer Hand				1									1
Sample Passer Asst.								1					1
Test House Asst.	1	1										1	1
Pattern Maker						1						1	
Casting Foreman										1			1
Foundry Foreman										1			1
Installation Men				1									1
Public Anal. Asst.				1									1
Salesman		1									1		
Inspector								1					1
No Occupation			1	1		1							3
	3	7	13	12	3	2	3	3		2	11	13	24

Professor Andrew[10] in presenting his report on the Intermediate Examination and Final Iron and Steel examination made a bitter attack on the poor standard of candidature. Comments from his report were " --- general impression is that the standard is very low indeed--- candidates have little or no idea of modern developments ------ lack of enthusiasm for the subject may be due to the subject being taught in an uninteresting manner ------- many candidates should never have been entered, their knowledge of the subject being almost pitiable, ----- a lack of understanding of the subject------ to carry weight with industry a higher standard must be obtained". In spite of these comments it is doubtful whether industry, collectively, knew what they wanted and if, in fact, much heed was taken of a qualification once it had been obtained.

The Author's own experience was typical of the day. He was placed on quality control, carrying out the wet analysis of Irons and Steels and wondering why. After six months he appealed to his chief to tell him why and one can remember his surprise and candour at the concern expressed. The chief metallurgist had no qualification himself and although a man of great experience he was not interested in the outcome of his junior's studies. A less zealous student may well have been deterred from pursuing his course.

In view of the poor Final results (TABLE II) it was necessary for the Advisory Committee to make special concessions in order that the pass rate might become more respectable.

It was resolved that in respect of the 1934 examinations only, the candidates who had passed the second paper in either Iron and Steel or paper A or B Non-ferrous but who had failed in the first paper - Physical Metallurgy should be informed that they may enter again in 1935 for Physical Metallurgy alone on payment of half fee and that the Institute be asked to carry forward the marks obtained by such candidates in the second paper in order to qualify. An additional concession was given to those candidates who had not fallen below 40% in any one paper and who had gained an aggregate of 50% in the two papers for the final examination. The amended results are shown in TABLE V but can hardly claim to make a significant difference from those processed in TABLE II.

TABLE V

Iron and Steel	No. of Candidates	1st	2nd	F	% Fail
	51	2	8	41	80

Although Professor Andrew felt that students were being entered for the examinations before they were properly prepared, Mr. Godsell[11] felt this not to be the case because of the fall-out in entrants in the three sessions, 1932,33 and 34. He felt the general position (TABLE VI) reflected the position in all the individual centres.

TABLE VI[12]

No. entering for Final Examinations	Year
135	1932
89	1933
73	1934

The greatest single issue that arose out of the high failure rate was the syllabus content and the interpretation of syllabus content. Professor Taverner[13] in advocating a re-appraisal of syllabus content pointed out that if questions were to be set out in some of the subject matter mentioned in the Intermediate syllabus, the students would, in his opinion, have to study the subject matter more deeply. He argued that the syllabuses were guides not only to students and teachers, but also to examiners and since the syllabuses were set out in such detail, it had to be presumed that the Committee wished an equally extensive examination of candidates' knowledge. Nevertheless modification to syllabus content was deferred on the grounds that one year was insufficient to judge reaction and to validate the syllabus content.

It must be said, however, that from this moment the Committee began to examine the problems more critically and attempted to rationalise their own thought on a sounder educational basis.

Andrew and Taverner [14] became the architects of new proposals. In their presentation they examined the scheme as accepted and drew attention to some anomalies viz:- All final students in ferrous and non-ferrous metallurgy took two papers.

1. Final Metallurgy

2. Iron and Steel

or

Non-Ferrous (Extraction (A)
or Working (B).)

The essential difference here was that the student taking Iron and Steel had to cover the whole subject which in fact included both extraction and working while the non-ferrous student, on the other hand, had only to take one section.

Again, students taking electro-metallurgy took intermediate and final without studying the principles of either ferrous or non-ferrous process metallurgy. This was regarded as being unsound and possessing obvious disadvantages. A further discrepancy was that candidates were asked to take only one final paper. Viewed from a technical standpoint it was considered that a knowledge of electro-metallurgy was far more important to process and extraction work than physical metallurgy (a question open to doubt in modern context) and that for heat treatment and the working of metals physical metallurgy was necessary. Equally it was considered that process metallurgy was necessary to electro-metallurgy.

Based on these conclusions it was suggested that the number of alternative papers at intermediate and final level should be increased from six to ten but that there should be several possible methods of grouping these papers permissible to a final candidate. It was recommended that every candidate should pass the intermediate grade and two final papers. The ten papers suggested were as follows:

1. Intermediate Grade (common to all branches)

2. Physical Metallurgy (FINAL GRADE) et seq. (All final candidates taking the working or manufacture papers are required to satisfy the examiner in this paper - one paper)

3. Ferrous Manufacture (two papers)

4. Ferrous Process (one paper)

5. Ferrous Process (two papers composed of:

   (a) advanced process

   (b) electro-metallurgy)

6. Non-Ferrous Manufacture (two papers)

7. Non-ferrous Process (one paper)

8. Non-ferrous Process (two papers composed of

(a) advanced process

(b) electro-metallurgy)

9. Electro-metallurgy (one paper -

(a) electrical technology

(b) met. processes)

10. Electro-metallurgy (two papers -

(a) electro thermal processes and/or

(b) electro extraction refining of metals).

Possible groupings were as follows:

(a) All students expected to take the intermediate examination and paper number 1.

(b) Ferrous process metallurgists to take papers 4 and 5.

(c) Non-ferrous process metallurgists to take papers 7 and 8.

(d) Working or heat treatment metallurgists to take papers 2 and 3.

(e) Non-ferrous working or heat treatment metallurgists to take papers 2 and 6.

(f) Electro-metallurgists to take papers 9 and 10.

In 1935 it was resolved by the Advisory Committee[15] that Professors Andrew and Taverner be invited to prepare syllabuses showing in full outline the quantity of the physical metallurgy that they proposed to allot to the different papers in which physical metallurgy would occur. By 1936 Professor Taverner[16] communicating with the Secretary of the City and Guilds Institute wrote- "------- I have found it virtually impossible to prepare a satisfactory draft of several syllabuses on the basis of previous discussion. I hold strongly to the view that these examinations are technological and vocational. They expect the candidates to have specialist knowledge of a section of a subject relative to their employment rather than a more general knowledge of the science as a whole. It would appear that specialisation in the subject of metallurgy should begin before the end of the third year of study, corresponding to the time required for the intermediate syllabus".

It was suggested that the intermediate examination should consist of two papers (a) a general paper, which all candidates would be required to sit and (b) the second to be sub-divided in the same way as the final grade. Draft syllabuses for the intermediate examination were prepared on the lines:

A. General
B. Non-ferrous Process
C. Ferrous Process.
D. Non-ferrous working
E. Ferrous working

Continuing his letter Taverner felt that considerable opposition and criticism would be displayed to a scheme of this kind based very largely on the limited staff available for tuition. He felt that no useful purpose would be served by submitting the syllabuses and further discussion was necessary by a small sub-committee. His final comment was "I feel very interested in the matter as I consider this syllabus can or will determine, to a very large extent, the metallurgical knowledge of those employed in the industry who will eventually hold positions such as shop foremen and under-managers".

Undoubtedly the thoughts behind the courses as devised by Taverner and Andrew, (and here were men suggesting a scheme for technicians although they didn't name it so,) were to have profound effects upon future development of metallurgy courses. It was the first time that deep educational thought had really permeated what had been a fact-giving exercise.

In January 1937 the second triannual period of appointment of members of the Committee expired and it was necessary therefore to re-constitute the Advisory Committee. The new Committee had its first meeting on 28th September, 1937. The representative from Tees-side on this Committee was Principal S. Fields of Constantine Technical College.

The Terms of Reference of the Committee were:

1. To review regulations and syllabuses for examinations in metallurgical subjects.
2. To make recommendation for the appointment of examiners.
3. To advise the Institute upon all matters connected with its examinations relating to metallurgical subjects whether such matters originate within Committee or referred to it by the Institute.

G. Thomson drew attention to the small number of work's operatives taking the examination. South Wales had 2,000 such operatives and only 200 were attending courses. He suggested that there was an urgent need for an examination of Lower Standard. It was considered that existing syllabuses were adequate for the type of student preparing for junior executive level and that the small number of entries may be due to candidates preferring to take examinations held by local organisations.

Although Middlesbrough was the largest producing area in Great Britain there was not a single entry for the examination in 1937.

TABLE VII shows the centres entering candidates for the intermediate examination and the final Iron and Steel examination, while TABLE VIII compares the results obtained over the three year period 1935-37.

TABLE VII[17]

Centre	Inter.	Iron & Steel
Crewe	-	1
Shotton	7	2
Workington	3	3
Consett	-	3
Swansea	4	2
Barrow	-	1
Scunthorpe	11	8
Chelsea	-	9
John Cass	-	2
Newcastle	2	-
Stoke	-	5
Wednesbury	13	5
Birmingham	6	11
Coventry	1	-
Bradford	2	-
Rotherham	3	2
Edinburgh	3	-
Glasgow	1	-
	56	54

TABLE VIII[18]

Grade	Year	Number	Pass 1st	Pass 2nd	Fail	% Fail
Inter.	1937	56	19	18	19	34
	1936	65	10	25	30	46
	1935	52	17	19	16	30
Iron & Steel	1937	54	11	16	27	50
	1936	71	19	19	33	46
	1935	70	17	16	37	52

By this time the classification of occupation was more realistically aligned to the course. Out of the 56 candidates at intermediate level only one was an engineering student, the other 55 were directly concerned with the metallurgical industry. The same was true of the Iron & Steel final examination.

It was quite obvious that the first task of the newly formed Committee was to revise examination schemes. Should the examination cater for the executive or the artisan type of student? The attention of the Committee was drawn to the fact that a scheme for a National Certificate in metallurgy had been mooted some years previously but had been rejected largely on the grounds of the small numbers of students. Such a National Certificate would meet the needs of the candidates of the executive type who were, at that moment, catered for by the external degree of the London University and the Associateship of Sheffield and Manchester.

Discussion at this time was centred on the need, while preserving an examination for the executive class, to make provision for the artisan. Professor Taverner[19] suggested sectionalising the intermediate examination. He argued that students found difficulty in covering the syllabus owing to the wide range of topics. The outcome would be to achieve two responses:

(1) A deeper appreciation of any one section

(2) Various sections would interest particular production areas.

The upshot of these discussions was to divide candidates into three groupings:-

(a) Those needing elementary instruction with an examination of lower grade

(a) than presently offered by the City and Guilds of London Institute.

(b) A City and Guilds Ordinary National Certificate or equivalent examination.

(c) External degree or Associateship examination, e.g. A. met. (Sheffield).

A sub-committee was formed to recast syllabuses on this basis[20].

The greatest problem of the sub-committee seemed to revolve round an attempt to provide a single syllabus to cover both the artisan and executive type student. Arising out of this problem were the issues of sectionalised courses and localised demands. Although the new schemes were not finalised until the session 1939-40 it is significant that in 1938 the Superintendent of the City and Guilds Institute informed the sub-committee that he had been investigating the cost per student of those examinations in which the number of entries was small and that it might be necessary to discontinue those examinations which attracted only a few candidates. He asked the Committee to consider this in their deliberations.

Undoubtedly they did, and although their re-actions go unrecorded the Committee succeeded in devising syllabuses for two sets of examinations in the place of one, namely for Iron and Steel operatives and for executives. The latter to have the title "Principles and Practices of Metallurgical Operations"[21] and contain six alternative papers at final level. These were:

(a) Principles of Metallurgical Analysis

(b) Principles of Physical Metallurgy

(c) Production of Iron & Steel

(d) Treatment of Ferrous Metals and Alloys

(e) Extraction and Refining of Non-Ferrous Metals

(f) Manufacture and Treatment of Non-Ferrous Metals and Alloys.

In designing these sections the Committee had constantly in mind the question of local requirements. Section (a) was a completely new section and this along with section (b) was regarded as being well suited to the requirements of students engaged in laboratories and who might later pass into the works.

It was not sufficient to have a theoretical understanding of section (a) only and candidates had to show a certificate of adequate practical experience in this subject before sitting the examination.

Section (b) Physical Metallurgy was no longer compulsory but was recommended as a desirable adjunct to the other sections. Appendix IV shows the syllabus content for the Intermediate Metallurgy examination, the Final Iron and Steel and the Physical Metallurgy examinations. Comparing these syllabuses with those of Appendix III it will be noted that the Intermediate Metallurgy scheme had been materially reduced in scope but that it remained common to all branches of metallurgy. It was intended that emphasis should be placed on general principles. An essential difference in the Final Iron and Steel scheme from that outlined in Appendix II was to separate Production from Heat Treatment and create two examinations where only one had existed. The philosophy behind this thinking was to bring the syllabuses within the attainment of a larger number of students. In Physical Metallurgy the content was so designed to bring an understanding of principles to students in both the ferrous and non-ferrous metal industries.

Included in this major revision were the conditions governing the award of a Full Technological Certificate. It became necessary to pass in any three sections of the final examination before qualifying for an award.

The introduction of the new section (a) - The Principles of Metallurgical Analysis - was largely due to the fact that a common method of recruitment was via the "work's laboratory". The young assistant was introduced to "Production" through the tedium of "wet analyses", it not being uncommon to find him determining in iron and steel samples, fifteen to twenty manganese, silicon, phosphorus, sulphur or carbons per day. He would follow this activity, and in many instances by making a rail journey, with at least three evenings per week attendance at the nearest technical college. His approach to metallurgical analyses would be soured by the insistence of the college that he should pay a fee for "breakables" and this probably led to replacement out of the "firm's" supply. The comparison between reality and need to have a fundamental understanding of all analytical techniques necessitated a comprehensive coverage of syllabus content and this involved a wide choice of questions at examination in order to meet all interests.

The period 1939-44 was essentially one of consolidation and self examination by the City and Guilds of their new schemes. It was not until 1944 that proposals were again mooted for the introduction of a National Certificate scheme[22]. This emanated from a review entitled "The Training of Metallurgists" with special reference to the Iron and Steel Industry and published under the aegis of the Iron and Steel Institute[23].

The supply, training and status of metallurgists was examined by the Iron and Steel Institute in an attempt to overcome the shortage of able staff. It was suggested that the introduction of a National Certificate in Metallurgy would provide objectives at which those continuing their education by attendance at part-time day or at evening classes could aim and that a desirable result would be to produce a "levelling up" of the standard of part-time education throughout the Country.

It was argued that the engineering and chemistry students had prescribed guide lines along which to move towards professional status but that the metallurgy student must often give undue attention to other subjects if he wished to win a nationally recognised qualification.

The effect of a year's national service was a problem to all students whatever the National Certificate scheme but it was apparent that the age of service or the course of instruction should be adapted to make the break come after the winning of the Ordinary Certificate.

It was indeed refreshing to find an industry prepared to examine itself critically. The Iron and Steel Industry was conscious of the fact that a large proportion of its most valuable men in managerial positions was drawn from that sector who had entered employment at the minimum school leaving age. It was observed that those entering industry would have no knowledge of the basic sciences and that the technical and scientific education must be undertaken after they entered employment. Even at this moment the industry was prepared to consider the implication of compulsory education on a part-time basis up to the age of eighteen. (How slowly the wheels of progress turn when one considers that twenty years have elapsed before any semblance of compulsion has been made and how sad that the industry did not suggest full-time integrated education at the time). In the education to be provided "essential elements will be the training in clarity of expression and in the understanding of the written and spoken word together with some education in the broad meaning of citizenship"[24]. The wisdom of this provision in which technological revolution is outstripping biological evolution was right. The sadness of the situation is, in fact, that too much lip service and too little reality has been placed on the teaching aspect of this recommendation.

In the Author's own experience he has noted a marked reluctance on the part of science students, in particular, to meet this challenge. The end of language and the complementary study subject in the secondary school represents the "end of schooling" for many of these young people and this leads to a resentment not only to the non-examinable subject but to the course as a whole. Although somewhat irrelevant to the historical development of National Certificates in metallurgy there are four factors which could contribute to the success of the complementary study and are of sufficient importance to be stated here. They are:-

1. Teaching of the highest quality based on communication, economic history and geography and so slanted to link with the main vocational content.
2. A need for sympathy and support on the part of industry in understanding the problem of (a) the student and (b) the college.
3. The need for secondary educationists to stress the importance of these subjects in ANY future study area.
4. Make the complementary study examinable.

It was considered that part-time education should provide facilities for students to attain a standard comparable to that obtained by study at a University, even though general education need not necessarily be so wide as to meet the requirements of matriculation examination.

Facilities for part-time education in metallurgy varied considerably throughout the Country, but on the whole compared unfavourably with those available in chemistry, mechanical and electrical engineering and with physics. Equipment, the approval of which was often difficult to gain, left much to be desired[25]. In paragraphs 79 and 80 of Command 6458 the Board of Education state "The standard of buildings and equipment in use have often been deplorably low. They compare unfavourably with those in countries which are "our competitors" in the World markets".

"A programme of capital expenditure of some £12,000,000 was contemplated before the war - the post war cost will be higher, but must be incurred". In 1956 the sum was £90,000,000.

The curricula of courses were not always appropriate to local requirements or, if adapted specifically to meet the needs of industry in the district, were not built upon a sufficiently broad basis of general science and thus failed to provide adequate opportunities for the students to gain qualifications which would be recognised on a National basis.

It was realised that the part which industry must play in encouraging part-time education was of paramount importance [26]. The document states - "The vocational training that has come into being within the system of public education has, in the main, not come in respect to any demand from industry but has depended upon the enterprise and tenacity of individual students anxious to equip themselves more fully to advance in life".

Release should be made easy for day-release attendance at both appropriate classes and private study periods and wherever possible a period of entire release prior to critical examinations should be arranged. Close co-operation between industry and the college should be maintained with the industrialist acting as part-time teacher. (Except for highly specialised topics the author does not consider that the "amateur teacher" is a wise choice in the current situation and while close links between industry and college are essential he is opposed to the extravagant use of this part-time teaching force).

Merit in part-time study by junior employees should be recognised by their employers. Assistance should be given in the payment of fees when tuition is not free.

Such recommendations were of great encouragement at a time when the introduction of a National Certificate in Metallurgy and a new professional institution were in the offing.

A Joint Committee comprising representatives of the Iron and Steel Institute, the Institute of Metals, the Institute of Mining and Metallurgy and the Board of Education was set up to formulate rules. Each of the first three bodies named expressed the wish that in evolving a National Certificate scheme consideration be given to the possibility of integrating the City and Guilds of London Institute examination in the Principles and Practices of Metallurgical Operations within the scheme.

In examining these proposals the City and Guilds Advisory Committee [27] asked HMI Blount to remind them of the conditions governing National Certificate schemes. After drawing attention to the importance of attendance by the student and to his progressive study, and to the place of the Joint Committee in examining course content, college provision and staff, he pointed to the fact that the examination was a college examination. It was possible however that colleges within the area of regional examining unions might use the examinations of that body but that such syllabuses would have to be approved by the Joint Committee and the examination papers assessed by the assessors in the prescribed way.

It was pointed out that since the Board of Education refused the application in 1930 for a National Certificate in Metallurgy on the grounds of (a) lack of numbers of students and (b) no professional institute of requisite standing to launch the scheme with the Board of Education, such joint work being a sine quo non of all

National Certificates, those interested in metallurgical education had devoted their energies, through the City and Guilds of London Institute, to the establishing of a comprehensive and high grade qualification for metallurgy students. The scheme placed great emphasis on the need for a well balanced group course of instruction and for the necessity of methodical grounding in the fundamental sciences.

The time had now come to reconsider the establishment of a National Certificate in Metallurgy because (a) there were three times as many students coming forward for instruction and (b) there had been considerable change in the status of the three Institutes.

It is of interest to examine the growth of entrants to examinations up to this time. These are set out in TABLE IX and show a remarkable increase at Intermediate level.

TABLE IX [28]

THE NUMBER OF CANDIDATES ENTERED FOR EACH SECTION

DATE	INTER	FINAL					
		A	B	C	D	E	F
1934	48			51			
1937	56			65			
1938	93			56			
1939	159			93			
1940	119	22	61	55	35	13	11
1941	200	35	81	64	35	7	7
1942	211	37	124	62	50	20	14
1943	206	39	149	112	83	19	49
1944	230	83	144	127	125	20	64

Other interesting statistics show an increase in the number of centres from eighteen to thirty three and a decrease in the type of occupation from nineteen to eight, the only misplaced personnel being clerical and operative entrants. By this time too, a greater understanding had been reached in what was expected of the students and this was reflected in a generally higher pass rate (approximately 55 - 65% pass rate).

These were the factors that provided the evidence for the City and Guilds of London Institute being an influential partner in the National Certificate provision and indeed the Inspectorate welcomed the collaboration that the City and Guilds were able to give.

In discussion, the Advisory Committee of the City and Guilds referred to a number of issues which suggested a general assent to the introduction of a National Certificate scheme. These included:

1. A viable administrative and examining unit from which experience could be drawn without duplication of schemes or manpower.
2. The metallurgist was now a being who operated in his own right and the anomaly that scientific help could come only from the chemist and technology only from the engineer was no longer true.

3. That proposals were being discussed for the formation of a single professional body and although a National Certificate may be a little premature in this context it was quite obvious that a definite qualification was now essential and the City and Guilds should work to this end.

In spite of these comments many of the old arguments were raised.

In view of the importance of the fundamental sciences couldn't a joint chemistry-metallurgy Ordinary Certificate fill the need? Was it proper to introduce a National Certificate scheme when there was no recognised professional institute? Would not industry be concerned if any attempts were made to scrap the City and Guilds qualification especially when the scheme suited process metallurgists as well as research metallurgists? It could well be that some of the wiser members of committee were able to foresee the difficulties that many were about to experience in treading the technological road.

At this time it is obvious that HMI Blount was the driving force behind the development and whilst not wishing to see the City and Guilds' course being discontinued he pointed out that it had certain defects[29]. There were no ancillary subjects in the intermediate grade scheme and in too many cases students were pursuing the course in colleges without proper equipment or even laboratory work at all. It was the Board of Education's intention to inaugurate the scheme by September 1944. Blount explained that the Board were being pressed by the Institution's concern to launch the scheme as soon as possible so that it would be in working order by the time the War ended. A sub-committee was formed to explore the possibilities of collaboration with the Joint Committee.

The Sub-Committee not only met on 29th June, 1944 to consider its own position but met also members of the Joint Committee at 4, Grosvenor Gardens. The outcome of these meetings was that the Advisory Committee of the City and Guilds of London Institute were prepared to support strongly the proposed National Certificate scheme provided that:

1. The candidates who obtained a National Certificate were exempted from at least some of the requirements for membership of the proposed professional institution.

2. That the City and Guilds of London Institute were asked to collaborate in the scheme. The Sub-Committee strongly urged that the value of the scheme would be enhanced if time were allowed for further consideration on the part of the interests concerned and to allow time to bring the new scheme to the notice of industry. Representatives from the Iron and Steel Institute were strongly of the opinion that the scheme was urgently needed and that consultation with industry should come after publication of the rules.

It would appear, from the harangue that took place at this meeting,[30] that the greatest weakness, as with so many of these issues, was in the lack of consultation (neither colleges nor trade unions had been consulted), and in the defensiveness of the ardent supporters of the older City and Guilds' scheme.

It was finally agreed that the starting date for the new National Certificate should be September, 1945 on the understanding that suitable courses at S1 and S2 standard should receive retrospective recognition.

Undoubtedly a lesson had been learnt, for in his closing remarks the Chairman said that the Board of Education should arrange to consult with the Association of Technical Institutes, the Association of Principals of Technical Institutes, the Association of Teachers of Technical Institutes, the Standing Joint Conference of the Regional Examining Union, professional and industrial organisations and the City and Guilds of London Institute[31].

In the ensuing meetings, and indeed it is quite obvious that the Board of Education intended to have its way, the most notable contribution came from consultation with the Association of Principals in Technical Institutes. It was agreed that the City and Guilds of London Institute and other Institutes should collaborate with the Joint Committee with a view to both the Intermediate and Final examinations of the Institute being used as alternatives to the assessed internal examinations provided:-

(a) that the City and Guilds of London Institute continued to award a Full Technological Certificate independent of the Higher National Certificate,

(b) that the Higher National Certificate awarded by the Joint Committee form a substantial contribution to the qualification and for corporate membership of the proposed new Institution of Metallurgists,

(c) that the Full Technological Certificate of the City and Guilds of London Institute be accepted on equal footing with a Higher National Certificate for corporate membership.

In January 1945 the Institute held a meeting with the Standing Conference of the Regional Examining Unions. The main considerations were (a) how to avoid duplication of examinations and (b) the place of the Institute in terms of the Ordinary and Higher National Certificate. At this meeting it emerged "in confidence" that a provisional council had met to consider a constitution for the new Institution of Metallurgy - the body ultimately concerned with the Joint Committee.

Principal Fields, speaking on behalf of the Constantine Technical College, said that the Northern Counties Technical Examination Council had not yet considered the proposed National Certificate scheme although only one centre in the area of Tees-side (i.e. Middlesbrough) was concerned. He felt that Constantine College would adopt the scheme but that with the small numbers of students coming forward for the Intermediate Examination a common examination for the whole Country would appear appropriate. He was strongly of the opinion that the Institute and the Examining Unions should work out an agreed scheme.

At the same meeting HMI Blount explained the Board of Education's wish with respect to what he called "A division of labour". It was that the Examining Unions should offer the Ordinary National Certificate only and that the City and Guilds of London Institute should offer both the Ordinary and Higher National Certificate.
It was considered undesirable to have too many bodies catering for the Higher National Certificate and since the

City and Guilds had previous experience in this level of work it was more appropriate that they should be responsible for this field of activity. The reason why the City and Guilds should offer the Ordinary Certificate was due to the fact that a number of areas were not covered by Regional Examining Unions. Blount also made the point that it was open to individual colleges to submit its own syllabuses at the higher level.

It was argued that at the Ordinary stage much the same syllabus content was wanted by everybody and that a unified scheme should be formulated. It was at the higher level where latitude was needed. Representatives of the four examining unions were invited therefore to serve on the City and Guilds Advisory Committee.

The City and Guilds Institute were now committed and in the discussions that followed the Head of Department of Metallurgy from Constantine Technical College was responsible for modifications which took place when syllabuses and schemes were being prepared. In his criticism, Grove drew attention to the disadvantages experienced by the "three - evening - a - week - student" and the " interference to attendance by shift working". In view of these remarks and on comparison with other National Certificates the Advisory Committee for metallurgy [32] agreed that:

1. The course should entail, in general, attendance on three periods a week for not less than 200 hours instruction per session.

2. It should be stated definitely that the standard of attainment for admission into the 2nd year of the course should be the equivalent of a General School Leaving Certificate in subjects comprising the 1st year of the course.

3. The curriculum for the 2nd year and for the 3rd year should be modified to embrace minimum requirements both in regard to the subjects and to the period of study.

One of the more difficult problems to resolve was that concerned with the pass mark of the City and Guilds examination (50% pass mark) and the National Certificate examination (40% pass mark). It was pointed out that the only conditions which might not be fulfilled in the

National Certificate were those of attendance and homework. In these terms it was quite possible for a student to satisfy the requirements for the Institute's Grouped course but at the same time fail the National Certificate examination. However it was finally agreed that the Institute would not issue a Grouped Course Certificate to candidates taking the City and Guilds examination and who failed to qualify for an award of an ONC in Metallurgy[33]. It was also to be understood that the Institute reserved the right to record the success of such a candidate in any City and Guilds examination at the intermediate stage which required a part qualification in connection with the award of the Institute's Grouped Course Advanced Certificate or a Full Technological Certificate in Metallurgy. In this connection an important point was raised concerning the candidate who had satisfied the Institute's Intermediate Grouped Course Certificate but who, at the same time, had failed to gain an ONC and who did not pursue his course. After consultation with the Ministry of Education[34], it was made clear that no objection would be taken to the view that at the end of a further three years the candidate in question may be awarded the Institute's Intermediate Group Course Certificate on the understanding that the Institute's Examination Board would satisfy itself that the student had good reason for not having continued his metallurgical studies.

It was also understood that the City and Guilds would be allowed to issue their own certificate to any candidate coming forward for a Higher National Certificate under Rules III who were successful in a single technological subject in the Institute's examination at the Advanced stage but who might not qualify for the award of the Higher National Certificate in metallurgy.

In terms of Rules III, the Institute was concerned with the arrangements regarding the assessments of the 3rd and 5th years of study. It was suggested that proposals be submitted to the Ministry that as a practical measure the Assessors appointed by the Joint Committee should serve on the City and Guilds moderating committee which year by year met with the Institute's examiners to review and adjust the several question papers. It was already understood that the Institute had undertaken to transmit the question papers so adjusted, to the Joint Committee for formal approval and for assessment of the candidates' scripts already marked by the Institute's examiners. In a letter dated 30th July, 1945 Dr. Burness for the Ministry, expressed his uneasiness about the possible repercussions with other examining bodies and expressed the hope that the Institute would accept the same arrangement in metallurgy as in other National Certificates. The Sub-Committee considered metallurgy to be in a unique position and in submitting the scheme to the Joint Committee further recommended that the Assessor should be invited, as a matter of administrative convenience, to attend meetings of the City and Guilds Moderating Committee. The procedure would help co-operation and lead to the right thinking in terms of the National Certificate.

The scheme of work for the new Intermediate or Ordinary National Certificate examination was as follows:

FIRST YEAR

Chemistry

Physics

Mathematics

SECOND YEAR

Physics

Mathematics and)
)
Engineering Drawing)

Chemistry and)
)
General Metallurgy)

THIRD YEAR

Chemistry

Physics

General Metallurgy.

The syllabuses for the subjects comprising this curriculum were not divided between the three years, the colleges being permitted such latitude to teach the content in the order best suited to meet the local need.

Another significant factor of this course of study was the presence of practical examinations in both Chemistry and General Metallurgy.

In the final examination it was envisaged that students would elect to study either ferrous or non-ferrous metallurgy. In any event it was emphasised that an essential part of the study should be devoted to practical work.

On the basis of the existing provision namely:-

(a) Principles of Metallurgical Analysis

(b) Principles of Physical Metallurgy

(c) Production of Iron and Steel

(d) Treatment of Ferrous Metals and Alloys

(e) Extraction and Refining of the Common Non-Ferrous Metals

(f) Manufacture and treatment of Non-Ferrous Metals and Alloys

the following alternative schemes were formulated

FOURTH YEAR

<table>
<tr><th>Ferrous Metallurgy</th><th>Non-Ferrous Metallurgy</th></tr>
<tr><td colspan="2">Section (A)
Section (B)</td></tr>
<tr><td>Section
(C) or (D)</td><td>Section
(E) or (F)</td></tr>
</table>

FIFTH YEAR

Ferrous Metallurgy	Non-Ferrous Metallurgy
Section (A)	
Section (B)	
Section not taken in the Fourth Year i.e. (D) or (C)	Section not taken in the Fourth Year i.e. (F) or (E)

Candidates for the Institute's Advanced examinations were expected, at the end of the fourth year to take the examinations in Sections (C) or (D) or in Section (E) or (F) according to the branch of metallurgy selected and at the end of the fifth year the examination in Section (A) and (B) and also the appropriate section not taken at the end of the fourth year.

The examinations in Section (A) and (B) consisted of written and practical papers while the other sections consisted only of written papers.

In order to gain a Group Course Certificate in metallurgy (Intermediate Grade) a candidate was required to pass (1) the Institute's examination in chemistry, physics, mathematics and engineering drawing in the same year or in a year prior to that in which the candidate passed the Institute's examination in general metallurgy or (2) the Institute's examination in metallurgy (Intermediate Grade) and who in the same year or in the previous year passed the appropriate examinations of an approved standard in chemistry, physics, mathematics and engineering drawing as held on behalf of, or by the governing body of a technical college.

The requirements for an advanced certificate were:- A pass at intermediate grade followed by passes in Sections A,B, C and D or A, B, E and F. To gain a Full Technological Certificate a student had to pass in one further subject, thus a ferrous metallurgist had to pass Section E and a non-ferrous metallurgist in Section C.

The revised regulations and syllabuses were specifically devised by the Institute's Advisory Committee (which in this connection included a representative from each of the four Regional Examining Unions) to allow of integration of the syllabuses and related examinations with the scheme for National Certificates in metallurgy established by the Ministry of Education under Administrative Memorandum Numbers 2 and 57 (Appendix VI) and Rules III (Appendix V).

Appendix VII sets out the syllabuses for this scheme and it was proposed that the examinations for these syllabuses should come into operation in the session 1945-46.

Apart from the introduction of the intermediate subjects little change was made at final level save for the inclusion of a six-hour practical examination in physical metallurgy.

Concurrently with the development of the National Certificate in metallurgy there was a widespread desire for a new organisation admitting only qualified metallurgists who met high academic and practical standards and having functions independent of but complementary to those of the Iron and Steel Institute and The Institute of Metals. With the goodwill of these two institutes The Institution of Metallurgists was founded in September 1945 and became a member of the Joint Committee for metallurgical education.

It is relevant to note that in its regulations the Institution grants exemption from the Licentiateship until December 1966 provided that:

1. The candidate is 21 years old.

2. Has passed before 1964 (a) the Intermediate examination and (b) the Full Technological Certificate (1st class) of the City and Guilds.

3. Three years experience in metallurgical science or practice.

or 1. The candidate is 21 years old.

2. Has obtained before 1964 a Higher National Certificate in metallurgy and has been notified in the pass list issued by the Joint Committee for National Certificate in metallurgy that exemption standard has been reached in at least three subjects of the Final examination (including endorsements).

Exemption standards will approach distinction and candidates claiming exemptions under this regulation must have obtained their Certificate at a College approved by the Institution for the purpose of this regulation.

or 3. Three years experience in metallurgical science or practice.

In effect, therefore, the Institution of Metallurgists became the instrument by which standards of educational attainment were set and in turn the Regional Examining Boards and Colleges were obliged to conform in order that the students would have the necessary entrance qualifications for membership of the Institution.

Throughout negotiations for the introduction of a National Certificate scheme in metallurgy Principal Fields of Constantine Technical College represented the Northern Counties Technical Examinations Council.

One of the objects of negotiation was to reduce the number of examining bodies which would operate under the scheme for the limited number of students expected to be forthcoming. No mention of this was made in City and Guilds records and since the Intermediate scheme was non-specialist in nature there would seem to have been a very good case for one scheme of work only. It was not, however, found possible to arrive at a satisfactory arrangement, and the Council[35], in common with other Examining Unions, proposed to prepare its own scheme.

The Northern Counties Technical Examinations Council first offered an ONC Course in Metallurgy in session 1946-47. The first final year of the ONC examination was held at the end of the session 1948/49.

Appendix VIII sets out the examination scheme prescribed by the Northern Counties. Although the scheme provides for four years of study as follows:

S.1	Chemistry	
	Physics	
	Mathematics	
S.2	Chemistry	
	Physics	
	Mathematics	
S.3	Inorganic Chemistry	
	Engineering Drawing	)
		)
	Mathematics	)
	General Metallurgy	
S.4	Physical Chemistry	
	Analytical Chemistry	
	Physical Metallurgy	

the S.1 year was regarded as a preparatory year and not part of the National Certificate proper.

A comparison of the syllabus content of this scheme with that of the City and Guilds Institute shows little difference in subject span although the subject headings at S.4 were different and indeed the Northern Counties headings would give the student the impression that he was studying subjects more closely allied to his industrial needs. By 1949 this scheme had been modified to read:

S.1	Chemistry
	Physics
	Mathematics
S.2	Chemistry
	Physics
	Mathematics
S.3	Inorganic Chemistry
	Physics
	Engineering Drawing and
	Mathematics

S.4 Inorganic and Physical
Chemistry
Physics
Metallurgy

By this time even the subject headings were becoming similar.

It is significant that only one student from Tees-side gained an Ordinary National Certificate in the first final examination in 1949. Appendix IX shows the results for Tees-side for the period 1947-57.

Throughout the following years both the City and Guilds of London Institute and the Northern Counties Technical Examinations' Council appraised their schemes "to keep abreast with technological development". In 1951 in the City and Guilds, attention was focussed on the similarity of the content of ancillary subjects in the courses for Fuel Technology, Petroleum Products and Principles and Practices of Metallurgical Operations.
In order to co-ordinate the subjects of these courses certain modifications were necessary and as a result a new format "Metallurgy" was to appear in the session 1953-54

(Appendix XI). This is to be compared with the syllabus content of the "Principles and Practices of Metallurgical Operations" 1952-53. (Appendix X). The most significant change was undoubtedly in the dropping of General Metallurgy from the second year of the course and concentrating the subject in the third and final year. Whether or not the emphasis on study of fundamental sciences had become too great is a factor that will receive attention in the discussion on the questionnaire. It is apposite, at this moment to note that the syllabus content was virtually unchanged.

In 1952 Major General Lloyd of the City and Guilds Institute was of the opinion that a wider measure of consultation was needed with the metallurgical industry and it was proposed that separate committees for the two operative courses (Iron and Steel and Non-Ferrous Metals) should be established and that these committees should report to a General Metallurgical Advisory Committee which, in turn, would cover the whole field of metallurgical education since it would be the parent committee for scheme 14 - Metallurgy.

In order to give greater flexibility it was suggested that more members be involved and that the General Committee should have a deputy chairman. Appendix XII shows the representation on the new committees. To say the least the members of these committees were able to bring a most powerful and comprehensive expertise to metallurgical education. Appendix XIII shows the terms of reference of the new General Committee and the two sub-committees.

The first meeting of the General Committee took place in February 1954 and one of the main educational discussions centred round examiners' comments on the use of written English and the hope that practical steps would be taken to improve standards. In discussion strong feeling that the Operatives' Courses would not be overburdened by the introduction of English. In terms of forward planning one is a little surprised and sad to learn the view expressed "------ that the large number of students at colleges was a hindrance in any attempt to provide additional instruction in the use of English". It was even suggested that employers could help materially by giving their staff greater opportunity for expressing their ideas in writing. The Chairman considered that students in the main Metallurgy course should be capable of coherent expression of ideas and expressed the wish that the matter should be brought to the attention of the Ministry of Education.

In appraising the syllabuses the Moderating Committee for the 1953-54 examinations reported "At first light, it may appear that the current syllabus has been drastically revised. This is not quite the case. A few additions and omissions have been made, but in general the aim has been to simplify and clarify....... More attention is to be given to principles rather than detailed description".

TABLE X

(Intermediate Examination Results)

Subject	Year	City & Guilds		Northern Counties	
		No. of Cand.	% Pass	No. of Cand.	% Pass
General Metallurgy	1953	181	47	40	73
	1954	215	72	47	77
	1955	226	56	-	-
	1956	213	72	74	76
Chemistry	1953	5	80	15	67
	1954	6	83	17	83
	1955	0	-		
	1956	1	-	32	75
Physics	1953	50	50	15	NA
	1954	6	50	20	60
	1955	0	-		
	1956	2	100	36	61

Table X shows a comparison of the City and Guilds results with those of the Northern Counties for the years

1953 to 1956 at Intermediate level. The significance of these figures is in the marked falling off in the number of candidates entering for the ancillary subjects, chemistry and physics, when compared with the main subject general metallurgy, in the City and Guilds examinations. Although the overall number of students taking the Northern Counties examinations was not so great, it can be seen from the Table that there was a growth trend in the number of students taking chemistry and physics. While it is true that there was an increase in the numbers of students passing in general metallurgy, the results were not as satisfactory as they first appeared to be because too many students were gaining a weak pass as a result of excellent compensatory marks in the practical examination.

In 1955 Rules III were revised. The only notable modification was the introduction of the Endorsement Certificates for attachment to National Certificates (Appendix XIV) paragraph 2(g).

By 1956 concern was being expressed at the marked decline in numbers not only in some of the advanced sections of the City and Guilds examinations but particularly so in the intermediate ancillary subjects. The Chairman of the General Committee thought it might be advisable to replace the Institute's common ancillary examinations by external examinations.

It was at this meeting[36] that first mention was made of the need for a recognised qualification intermediate between Operative and the National Certificate type of examination and in 1957 attention was drawn to a 50% wastage in Ordinary National Certificates and the Committee recommended that the Institute should explore the possibilities of establishing a "Technicians' Course" in metallurgy.

The accent was now on a new philosophy, the place of the technician, the better-than-operative but the not-so-good as National Certificate student.

The City and Guilds of London Institute put out a questionnaire (Appendix XIV) and the replies are set out in Appendix XV. In attempting to analyse the replies from members of the committee one is conscious of the uncertainty and lack of conviction of those who ought to have been committed to the scheme. Briefly the replies to the questions may be summarised:-

1. The numbers attending the course would be small.

2. A slowly increasing demand.

3. Lancashire and North West Coast

   Birmingham

   North East Coast

   Sheffield and Rotherham

   South Wales

   North London

4. Quality Control

5. A failure rate of 50-60%.

The most valuable contribution to this questionnaire was received from Tube Investments Ltd., (Appendix XVI) with thirteen organisations contributing to the reply. While there was no clear demarcation between the arguments certain points emerged:-

1. The need for incentives,

2. a higher age level involved,

3. more metallurgy in the course.

4. The opportunity to transfer from Technician to National Certificate course and vice versa.

In this Appendix an interesting comparison is made between ONC and HNC successes, some 50% of the students gaining ONC and 78% gaining HNC. This Nationally agreed low pass rate at ONC Level was indeed a reason for assessing the scheme.

From the evidence it would seem that educationists were in favour of a Technicians' course while industry considered that there was limited value only in this type of provision. There were two questions to be resolved as far as the Institute was concerned.

1. Was it any longer appropriate that they should continue to conduct examinations at the existing Intermediate and Final level?
2. Was there any prospect of industry employing the wastage from National Certificates as an identifiable category for whom a course could reasonably be devised?

The development of National Certificates may well involve more pure science and move away from its parallel position to the City and Guilds examinations. With some modification the existing City and Guilds scheme might cater for students for whom the

National Certificate was not suitable.

A Sub-Committee was formed with a remit to examine not only the possibilities of developing a Technicians' course but also to consider the intermediate and final schemes. Undoubtedly the timely appearance of the White Paper "Better Opportunities in Technical Education" was to affect the thinking of the Sub-Committee and by June 1961 the Institute's Examining Board had approved a recommendation that the ancillary subjects Physics, Chemistry, Mathematics and Engineering Drawing should be discontinued after 1961. Table XI shows the decline in these subjects and General Metallurgy from 1954 - 61 and the % pass rate.

TABLE XI

	Year	No. of Cand.	Pass	Fail	% of Passes
General Metallurgy	1954	215	155	60	72.1
	1955	226	126	100	55.7
	1956	213	148	65	69.5
	1957	164+28*	107	57	65.2
	1958	163+36*	112	44	73.0
	1959	184	124	60	67.4
	1960	139	87	52	62.6
	1961	108	84	24	77.7

*Candidates taking examination for National Certificate purposes only

	Year	No. of Cand.	Pass	Fail	% of Passes
Mathematics	1954	1	1	-	100.0
	1955	No candidates			
	1956	No candidates			
	1957	16	13	3	81.2
	1958	8	5	3	62.5
	1959	3	1	2	33.3
	1960	7	2	5	28.6
	1961	2	1	1	50.0
Engineering Drawing	1954	1	1	-	100.0
	1955	No candidates			
	1956	1	1	-	100.0

	Year	No. of Cand.	Pass	Fail	% of Passes
Engineering Drawing contd.	1957	6	6	-	100.0
	1958	5	5	-	100.0
	1959	1	-	1	0.0
	1960	2	1	1	50.0
	1961	1	-	1	0.0
Physics - 1st Paper	1954	4	1	3	25.0
	1955	No candidates			
	1956	1	-	1	0.0
	1957	14	6	8	42.8
	1958	10	3	7	30.0
	1959	7	1	6	14.2
	1960	6	4	2	66.7
	1961	5	2	3	40.0
Physics - 2nd Paper	1954	2	1	1	50.0
	1955	No candidates			
	1956	1	-	1	0.0
	1957	No candidates			
	1958	9	4	5	44.4
	1959	3	1	2	33.3
	1960	4	2	2	50.0
	1961	6	1	5	16.6

	Year	No. of Cand.	Pass	Fail	% of Passes
Chemistry					
	1954	6	5	1	83.3
	1955	No candidates			
	1956	2	2	-	100.0
	1957	No candidates			
	1958	2	2	-	100.0
	1959	5	5	-	100.0
	1960	3	3	-	100.0
	1961	6	5	1	83.3

Throughout the period January 1959 to February 1962 no meeting of the General Advisory Committee for Metallurgical subjects took place although the Sub-Committee was very active. In their deliberations members had expressed the view that the educationists were right in pressing for the Technician Course. Also they had taken into account the revised membership requirements of the professional bodies, a report on "The Recruitment and Training of Technicians" and the White Paper - Command 1254. Emphasis was placed on the scheme being self-contained and the students taking this course should not be regarded as being National Certificate rejects. Although the Sub-Committee had given careful consideration to the transfer of a student from the Technician Course to that of a National Certificate they were not in a position to legislate for this transfer. Suggestions were made that students who had completed the Metallurgical Technician's Certificate might be suitable for transfer to the beginning of a Higher National Certificate course, but members were of the opinion that a comparison of syllabus content of the two schemes would show this to be impossible. This underlined the importance of correct selection for the appropriate course in the first instance.

The General Advisory Committee for Metallurgical subjects at its meeting on Wednesday 14th February 1962 resolved to recommend to the Institute's Examining Board:-

(a) The Phased Discontinuation of Subject 14 - Metallurgy (the last Intermediate examination 1963; the last Advanced examination 1965).

(b) The adoption of the proposed scheme for Metallurgical Technicians in two parts

(1) Metallurgical Technician's Certificate.

(2) Metallurgical Technician's Advanced Certificate.

The use of the City and Guilds examinations as a means to gain a National Certificate had come to an end. It had taken twenty years of syllabus appraisal, scientific growth and high failure rates to make the Institute recognise the need for change. The early introduction of metallurgical topics in the scheme (Appendix XVII) had given a purpose to the course, at any rate, to the student. Indeed the scheme was now offering more metallurgy at an earlier stage than that prescribed in 1933. It is significant too, that many students, because of their background and work environment would have derived more value and certainly more success in 1933 had this type of course been available.

The last event coincident with the eclipse of the National Certificate scheme through the City and Guilds Institute has been the pronouncement of the Institution of

Metallurgists. By the end of December 1966 a Higher National Certificate no longer gave exemptions from the Institution's examinations. It could well be that the change in emphasis of the work situation has created a wider gap in the education of the Technologist and his assistants than hitherto existed. It could well mean that the development of the Technician course through the "Power-House of Examinations"[37] will lead to the total eclipse of the National Certificate in Metallurgy.

Summary of Chapter I

(a) The development of the City and Guilds of London Institute courses in metallurgy after they had been taken over from the Royal Society of Arts in 1881.

(b) The need to study ancillary science subjects in order to tain a full understanding of the Iron and Steel Manufacture.

(c) The Concordat. The need for City and Guilds of London Institute to seek approval from the Board of Education to conduct intermediate examinations.

(d) The development of a group course and the disastrous results of the first set of examinations - 50% failure at intermediate stage, 92% failure in Iron and Steel and 75% in Physical Metallurgy at final stage. The lack of selection for the course and the wide range of occupations of the students taking the examination.

(e) The need for reappraisal of syllabus content as a result of poor examination answers - The introduction of the course 'Principles and Practices of Metallurgical Operations' with a new section on Metallurgical Analysis.

(f) The growth of the number of students taking the metallurgical course led to the recommendation in 1944 for a National Certificate in metallurgy.

(g) The formation of a Joint Committee for metallurgy and the formation of the professional body known as the Institution of Metallurgists.

(h) The City and Guilds of London Institute to use their scheme for National Certificate purposes.

(i) The developments of National Certificate schemes in colleges and the decline in the use of the City and Guilds of London Institute scheme for this purpose.

(j) The change of the name of the metallurgy course 'Principles and Practices of Metallurgical Operations' to Metallurgy in session 1953-54.

Chapter II

An Examination of Students' Records at Tees-side Colleges 1957-58 to 1962-63

The events of history, recent developments in metallurgical science and technology, a substantial increase in the number of colleges presenting students for National Certificate examinations[38], observations made in the report of the Central Advisory Council for Education (England)[39] and, in particular, the experience observed in Appendix I of this report - all these indicate that useful information relating to the contemporary situation in metallurgical education could well be obtained by an examination of students' records.

Standardisation of Nomenclature of National Certificate Courses in Metallurgy.

During the period under investigation there were changes in nomenclature both at national and local level and in order to avoid any misinterpretation of a given "year" of the course it will be helpful to define the nomenclature that is to be used as standard throughout the text.

The scheme, as originally conceived by the Northern Counties Technical Examinations Council[40] provided for a pre-National Certificate year designated S1. The S2, S3 and S4 years constituted the Ordinary National Certificate proper and came under the regulations of the Joint Committee. In 1961 the Northern Counties re-classified their scheme to read S0 (pre-certificate year) S1, S2 and S3 years.

It became apparent once the inspection of students' records was begun that the old nomenclature presisted and much care and time had to be devoted to the unscrambling and reconciling of the two systems. In order to make comparison with the report of the Central Advisory Council for Education all records were standardised on the basis that the S3 year was the final year of the Ordinary National Certificate.

In these terms the S2 and S3 years equate to the 01 and 02 years of the new National Certificate in science[41] as shown in the following table:

TABLE XII

Course	Nomenclature			
	CAC for E	NCTEC		
	1959	1946	1961	1963
Pre-National		S1	S0	G1
	S1	S2	S1	G2
O.N.C.	S2	S3	S2	01
	S3	S4	S3	02
H.N.C.	A1	A1	A1	H1
	A2	A2	A2	H2

Another difficulty encountered in extracting information at the S0, S1 and S2 stages was that colleges bracketted both Chemistry and Metallurgy students' records together since both types of students were pursuing a common course. In turn no separation of course records were made by the Northern Counties Technical Examination Council since they set a common examination for both groups. It is unwise to apportion responsibility under these circumstances, but in an educational situation where common activity was adjudged to satisfy differing vocational needs, it is not unreasonable to have expected colleges to log records by the specialist nature of the course. Administrative convenience cannot be accepted as an excuse for omitting to record such data. In the new scheme "National Certificate in Science", colleges could well differentiate between groups i.e. chemists, physicists, biologists and metallurgists in order to make comparisons and to encourage staff to show a greater enthusiasm for pedagogical investigation.

Survey of Records

The Tees-side conurbation referred to in this survey includes five technical colleges. They are Cleveland (Redcar), Constantine and Longlands (Middlesbrough), Stockton and Billingham, and West Hartlepool.

All the colleges have been concerned with S0, S1 and S2 years while Constantine alone has provided the S3 year of the Ordinary National Certificate and the A1 and A2 years of the Higher National Certificate. Of these colleges, Cleveland was new in 1957 and Longlands in 1959. At this time Longlands assumed responsibility for development of the S0, S1 and S2 years and which had been administered previously by Constantine, the senior college in the authority.

Appendix XVIII contains a record sheet of the type compiled from individual enrolment forms and college record cards, all of which were different in format for each of the colleges and yet each college was searching essentially for the same kind of information. Where education is based on the premise that several contributory colleges will feed to a main centre there are obvious advantages in having a common enrolment form and record card. Appendix XIX shows a typical data sheet used to transfer information to a punch card system.

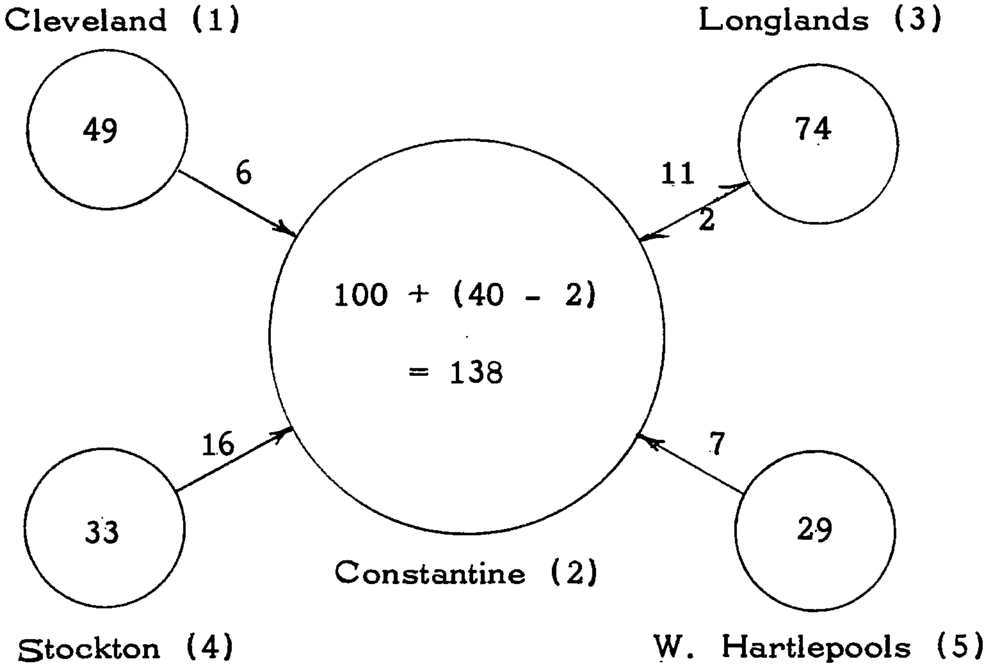
In all, 323 individual student records were examined from the five colleges over a period of six sessions (1957 - 1963) Appendix XX. They represented the total student population studying in part-time day release courses. The distribution of the student population within the five colleges during this time was as follows:-

Table XIII

College	No. of Students
1. Cleveland	49
2. Constantine	138
3. Longlands	74
4. Stockton	33
5. West Hartlepools	29
Total	323

In the Constantine total of 138 were included 40 students transferred from the other four colleges. Two students were transferred from Constantine to Longlands at the inception of this new college. Diagram 1 shows the distribution and transfer of students between the five colleges.

DIAGRAM 1


Cleveland (1)
49
6
Longlands (3)
74
11
2
100 + (40 - 2)
= 138
16
7
33
29
Constantine (2)
Stockton (4)
W. Hartlepools (5)

The survey is concerned with part-time day release courses in metallurgy and therefore the first contact of student with college was after completion of the secondary school course and after appointment to a job in metallurgy. In effect, the only selection to the courses that was made was that governed by Joint Committee regulations Appendix XIV namely the right number and kind of G.C.E. '0' level passes to enter S2 year, a G.C.E. course or equivalent without G.C.E. passes in the appropriate subjects - S1 entry and a non-examination secondary school four year course - S0 entry.

Type of Schools and Jobs

In the first instance, therefore, it is logical to look at the type of school and the type of job chosen by the students in the survey. Table XIV sets out this information and reveals some interesting points:-

1. Entrants to the National Certificate course in metallurgy came predominantly from grammar schools - 79%. It is interesting to compare this figure with those quoted in the report of the Central Advisory Council for Education - England[42].

It is almost three times as great as the figure quoted for engineering and twice as great as the figure for all National Certificates.

2. The percentage of technical and modern school entrants were accordingly lower, the technical school figure of 9% being conditioned partly by local provision or lack of provision, and partly by the emphasis placed on the grammar school.

3. The modern school entrants - 12% were confined almost exclusively (97%) to the Middlesbrough - Cleveland catchment area. The highest percentage of modern school entrants attending any one college was 26% at Cleveland undoubtedly as a result of the low percentage (± 18%) of 11+ transfer students to the grammar school.

4. Out of a total of 225 grammar school entrants 174 (77%) were placed in jobs of a quality control nature. Many of these students would have been better served by a less academic

Table XIV

Type of School	Number of Students		Number of Students in each College					Number of Students in each type of job		
			1	2	3	4	5	Quality Control	Engineering Application	Research Development
Modern	35	Quality Control	13	2	10	1	-	26		
		Engineering Application	-	4	2	-	-		6	
		Research Development	-	1	2	-	-			3
		Total	13	7	14	1	-	26	6	3
Technical	25	Quality Control	2	7	2	1	7	19		
		Engineering Application	-	2	-	3	-		5	
		Research Development	-	1	-	-	-			1
		Total	2	10	2	4	7	19	5	1
Grammar	225	Quality Control	28	60	46	18	22	174		
		Engineering Application	1	2	2	9	-		14	
		Research Development	5	21	10	1	-			37
		Total	34	83	58	28	22	174	14	37
	285	Grand Total	49	100	74	33	29	219	25	41

technician type of course and the absence of selective type courses such as existed in the field of engineering and the tradition of the Iron and Steel industry to give preference to grammar school entrants + were major factors contributing to this situation.

<u>Age of Students</u>

Commensurate with the high percentage of grammar school entrants to National Certificate courses in metallurgy, the age of leaving school was higher than that recorded in the Crowther Report[43], the major differences occurring in the 15, 16 and 17 age groups.

TABLE XV

	Age on leaving school				
National Certificate	15	16	17	18	19+
	%	%	%	%	%
Metallurgy survey	11	61	21	5	2
All National Certificates	46	41	9	3	1

\+ Author's experience in Iron and Steel industry.

A more pertinent consideration however is the age at which the student entered the National Certificate course and the following table makes comparison between the age of leaving school and the age of entry to the metallurgy course:

TABLE XVI

Metallurgy survey	15	16	17	18	19	20-25	26-42
	%	%	%	%	%	%	%
Age on leaving school	11	61	21	5	2	-	-
Age on entering course	3	54	19	8	6	8	2

The reasons for the differences between the two sets of figures were as follows:

1. Between the ages of 15 - 19 young people were experimenting with various jobs and did not begin a metallurgical career immediate upon leaving school. Examples of this are students who transferred from mechanical and electrical courses to metallurgy and indeed one student had been a shop assistant before entering the iron and steel industry.

2. In the two age groups 20-25 and 26-42 older

employees who were in one of two categories (a) clerical and (b) operative had been selected for laboratory duty and had been given the opportunity to attend the course.

Place of Employment

The students came from seventeen different Companies and the distribution is set out in Table XVII. It is noteworthy that the first five firms in this table account for 93% of the student population and the first eight firms for 97% of the students. This is an important factor in considering an integrated programme of education and training. Although the two Companies Dorman Long and South Durham Steel and Iron have a number of separate plants, the fact that five firms only provided 93% of the students attending National Certificate courses in metallurgy and the fact that a similarity in job specifications can be traced throughout these firms provided an excellent opportunity for selection, induction training and college education, particularly if the educational content had been rationalised within one college.

Table XVII

Firm	No. of Students	Expressed as % of sample
1. Dorman, Long and Co. Ltd.	151	53
2. South Durham Steel and Iron Co. Ltd.	52	18
3. I.C.I. Co. Ltd.	32	11
4. Head, Wrightson and Co. Ltd.	20	7
5. Skinningrove Ironworks Ltd.	10	4
6. B.I.S.R.A.	4	
7. Davy United Ltd.	4	
8. Darlington Forge Ltd.	3	
9. Darlington Wire Mills Ltd.	1	
10. Ashmore, Benson, Pease and Co. Ltd.	1	
11. Blacket, Hutton Ltd.	1	7
12. E. Hind and Co. Ltd.	1	
13. British Titan Products Ltd.	1	
14. Caterpillar Tractors and Co. Ltd.	1	
15. KADO Ltd.	1	
16. Richardson, Westgarth and Co. Ltd.	1	
17. Whessal Ltd.	1	
Total	285	100

A comparison of the type of Job against the number of '0' levels gained by the students.

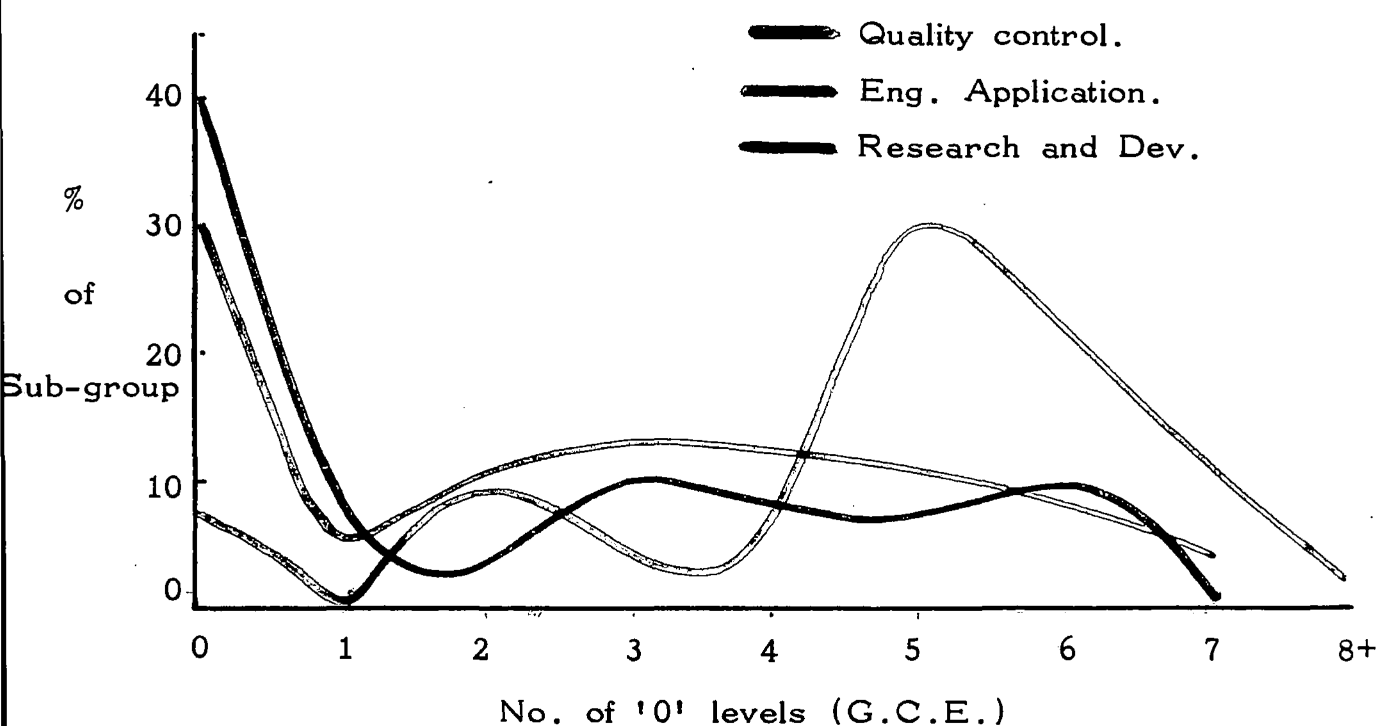
A further investigation was made to compare the number of '0' levels gained by students and the types of jobs they elected to follow. This information is summarised by college in Table XVIII.

TABLE XVIII

Job Type	College	Number of Students gaining the following number of G.C.E. '0' levels 0	1	2	3	4	5	6	7	8+
I Quality Control	1	20	2	2	2	5	6	4	2	-
	2	11	4	9	8	12	10	7	8	-
	3	14	3	8	16	6	4	4	3	-
	4	6	1	4	2	4	2	1	-	-
	5	13	3	-	3	2	3	4	1	-
	Total	64	13	23	31	29	25	20	14	-
	%	29	6	11	14	13	12	9	6	-
II Engineering Application	1	-	-	-	-	-	-	-	1	-
	2	4	1	1	-	-	1	1	-	-
	3	2	-	-	-	1	-	1	-	-
	4	4	1	-	3	1	1	1	-	1
	5	-	-	-	-	-	-	-	-	-
	Total	10	2	1	3	2	2	3	1	1
	%	40	8	4	12	8	8	12	4	4
III Research Development	1	-	-	2	-	-	1	1	1	-
	2	1	-	2	1	3	7	5	3	1
	3	2	-	-	1	-	4	3	1	1
	4	-	-	-	-	-	1	-	-	-
	5	-	-	-	-	-	-	-	-	-
	Total	3	-	4	2	3	13	9	5	2
	%	7	-	10	5	7	32	22	12	5

Plotting curves for the percentage in each '0' level number (Diagram 2) shows that the percentage of students with a greater number of '0' levels was greatest amongst those working in research and development while a reverse trend was evident in respect of the other two groups.

DIAGRAM 2



Another salient point was brought out in Table XVIII in that it showed that 40% of the students in quality control occupations had four or more '0' level passes and this would suggest that firms may well have been seeking personnel with qualifications greater than those required to perform simple routine jobs and this is borne out by the long and traditional practice of using the National Certificate as the only channel for professional training and education. Although it offered the route to professional status for a few, the majority never gained a recognised qualification. This is well-illustrated in the section concerned with pass and failure rates at various stages of the course.

The poor entry qualifications at Cleveland College (Appendix I) was one of the reasons for making this investigation. It was a disturbing fact that, although there was a high grammar school intake, 55% of the students had three or less GCE '0' level passes and indeed 27% had no '0' levels at all. The Cleveland College intake showed that 53% of the students had three or less GCE '0' level passes and this is very close to the percentage in the total sample, but the percentage with no '0' level passes (41%) is considerably higher than in the total sample. Table XIX summarizes the number of '0' level passes by college only. The results for College 3 and the unmodified results for College 2 are atypical. College 2 results included students who had entered the S3 year with GCE 'A' level passes (a situation not applicable to the contributory colleges) and also several ex-university students. Also the provision in College 2 for S0-S2 study ended in 1959. College 3 offered courses S0-S2 from 1959 only. Since Colleges 2 and 3 were in the same education authority with comparable facilities it seems reasonable to pool the S0-S2 years from these colleges. Thus all years of the survey are covered and the total result of Colleges 2 and 3 may be compared in the modified form with those of the other three colleges.

TABLE XIX

College	Number and percentage of students at each college gaining the following number of '0' levels					
	0		0 - 3		4 - 8+	
	No.	%	No.	%	No.	%
1	20	41	28	57	21	43
2	16	16	42	42	58	58
3	18	24	46	62	28	38
4	10	30	21	64	12	36
5	13	45	19	66	10	34
2 modified	6	19	18	56	14	44
3	18	24	46	62	28	38
Total	24	23	64	60	42	40

The high proportion of students with no '0' level successes at Colleges 1 and 5 may be attributal to the high percentage of modern school entrants (27%) and technical school entrants (24%) respectively.

Comparing the corrected value for the Colleges 2 and 3 with Colleges l, 4 and 5 in succession it is interesting to note how closely the percentage gains in the 0.3 and 4 - 8 '0' level bands approximate.

Finally an analysis of variance was made to determine how the number of '0' levels showed variability with the components of college and job (Table XX).

TABLE XX

Analysis of variance of the number of '0' level subjects obtained by students in different colleges and for the three different jobs

Job	College	n	Ex	Ex^2	$\frac{(Ex)^2}{n}$	$E'x^2$	Mean No. of '0' levels
	1	43	100	500	232.588		2.326
I	2	69	246	1198	877.043		3.565
Qual.	3	58	166	666	475.103	1851.204	2.862
Control	4	20	47	185	116.263		2.350
	5	29	66	330	150.207		2.276
	Total	219	625	2879			
		(N)	(T)	(S)	C = 1783.676		
					Total S sq = 1095.324		
	1	1	7	49	49.000		7.000
II	2	8	14	66	24.500		1.750
Eng.	3	4	10	52	25.000	189.250	2.500
Appl.	4	12	33	169	90.750		2.750
	5	0	-	-	-		-
	Total	25	64	336			
		(N)	(T)	(S)	C = 163.840		
					Total S sq = 172.160		
	1	5	22	118	96.800		4.400
	2	23	113	631	555.174		4.913
III	3	12	56	330	261.333	938.207	4.667
Research	4	1	5	25	25.000		5.000
	5	0	-	-	-		-
	Total	41	196	1104			
		(N)	(T)	(S)	C = 937.000		
					Total S sq = 167.000		

Pooling all colleges for each job

Job	College	n	Ex	Ex^2	$\frac{(Ex)^2}{n}$	$E'x^2$	Mean No. of '0' levels
I	All	219	625	2879	1783.676		2.854
II	All	25	64	336	163.840	2884.516	2.560
III	All	41	196	1104	937.000		4.780
	Total	285	885	4319			
		(N)	(T)	(S)	C = 2748.158		

Pooling all jobs for each college

Job	College	n	Ex	Ex^2	$\frac{(Ex)^2}{n}$	$E'x^2$	Mean No. of '0' levels
All	1	49	129	667	339.612		2.633
All	2	100	373	1895	1391.290		3.730
All	3	74	232	1048	727.365	2827.414	3.135
All	4	33	85	379	218.940		2.545
All	5	29	66	330	150.207		2.276
	Total	285	885	4319			
		(N)	(T)	(S)	C = 2748.158		
					Total S sq = 1570.842		

Three investigations were made.

1. Relating to Job I (Quality Control) only

Source of Variation	d.f	S.Sq.	Mean Sq.	Variance Ratio	Whether Significant
Between Colleges	4	67.528	16.882	3.5	At 5% *
Within Colleges	214	1027.796	4.803		Not at 1%
	218	1095.324			

The aim of this analysis was to determine whether the mean number of '0' levels obtained by students in the different colleges varied significantly from College to College and whether any differences indicated could be accounted for solely in terms of chance variance. Chance alone would not provide an explanation of the differences which are in fact observed in the final column (Whether significant). Considering the two extremes it would appear that the differences between College 2 and College 5 are worthy of note. As explained earlier College 2 is somewhat atypical but within the limits of this analysis it would appear that students attending College 2 have a greater number of '0' levels than College 5. To a lesser extent it is also true when College 2 is compared with College 3, colleges within the same authority, and this would suggest that College 2 was paying more attention to the number of '0' levels gained at entry.

2. Relating to all three types of Jobs pooled

Source of Variation	d.f	S.Sq.	Mean Sq.	Variance Ratio	Whether Significant
Between Colleges	4	79.256	19.814	3.72	At 1% *
Within Colleges	280	1491.586	5.327		
	284	1570.842			

This relationship shows a similar distribution pattern and re-inforces the conclusion drawn in relation to Job 1 above.

3. Relating to all five colleges pooled.

Source of Variation	d.f	S.Sq.	Mean Sq.	Variance Ratio	Whether Significant
Between Jobs	2	136.358	78.129	15.34	At 1% *
Within Jobs	282	1434.484	5.087		
		1570.842			

*Fisher's distribution - A first course in Mathematical Statistics

Weatherburn - Cambridge University Press pages 198 and 199.

The aim of this analysis was to determine whether the students employed in the different types of job showed statistical significant differences in the mean number of '0' levels which they obtained. There are significant differences and examining the table it is noted that students employed in Job III (Research) are a superior group to the others, and this confirms what is to be expected.

Inspection of Course Work and Examinations

Before investigating the Tees-side results in detail it is relevant to compare firstly the Northern Counties Technical Examinations Council results with those of the rest of England and Wales and secondly the Tees-side results with those of England and Wales.

Table XXI shows the comparison between the Northern Counties and the rest of England and Wales. Applying the Chi-squared test to these results (where $x^2 = \sum \frac{(0 - E)^2}{E}$ and where 0 is the observed frequency and E the expected frequency), it is seen that statistical differences do occur.

Over the six years of the survey, three of the years 1960, 1961 and 1962 show no statistical differences between the results of the Noethern Counties and the rest of England and Wales. There are statistical differences in the years 1959 and 1963 and a high statistical difference

TABLE XXI

Comparison of results between the Northern Counties and the Rest of England and Wales

Ordinary National Certificates

	58			59			60			61			62			63		
	E	P	F	E	P	F	E	P	F	E	P	F	E	P	F	E	P	F
Rest of England and Wales	677	363	314	752	374	379	692	344	348	687	348	339	642	361	281	708	404	304
Northern Counties	51	10	41	61	18	43	51	24	27	45	27	18	39	20	19	53	20	33
Total	728	373	355	813	392	421	743	368	375	732	375	357	681	381	300	761	424	337
x^2 =	21.957			9.303			0.134			1.478			0.365			7.466		
d.f = 1	$P < .001$			$.001 < P < .01$												$.001 < P < .01$		
	SSS			SS			N.S.			N.S.			N.S.			SS.		

Total x^2 over six years = 40.703 (d.f. = 6)

$P < .001$

SSS

in 1958. In all three cases of significant difference the results showed a poorer examination success rate for the Northern Counties than for the rest of England and Wales.

When the results over the separate years are pooled and the Chi-squared test applied again, it is seen that the overall result shows a significantly higher percentage pass rate for the rest of England and Wales than for the Northern Counties.

Comparing the Tees-side results with the rest of the Northern Counties and with selected areas in England and with the rest of England and Wales the following results were obtained.

TABLE XXII

% Pass - Comparison between areas and the years of the survey

Area	Year 58	59	60	61	62	63	Total	Mean
England and Wales not included below	56	49	53	54	56	60	328	54.67
Tees-side	23	30	48	52	35	13	201	33.50
Rest of Northern Counties	27	29	48	45	56	50	255	42.50
East Midlands	21	42	23	24	48	21	179	29.83
U.L.C.I.	40	58	30	33	60	45	266	44.33
Total	167	208	202	208	255	189		
Mean	33.40	41.60	40.40	41.60	51.00	37.80		

Analysis of variance (unweighted means)

Source of Variation	d.f	S.sq.	Mean sq.	Variance Ratio
Between Areas	4	2286.47	571.62	3.38 *
Between years for the Country as a whole	5	845.73	169.15	< N.S.*
Interaction	20	2516.77	125.88	
	29	5648.97		

* Fisher's distribution - A first course in mathematical statistics, Weatherburn - Cambridge University Press pp. 198 and 199.

From this analysis it can be seen that:-

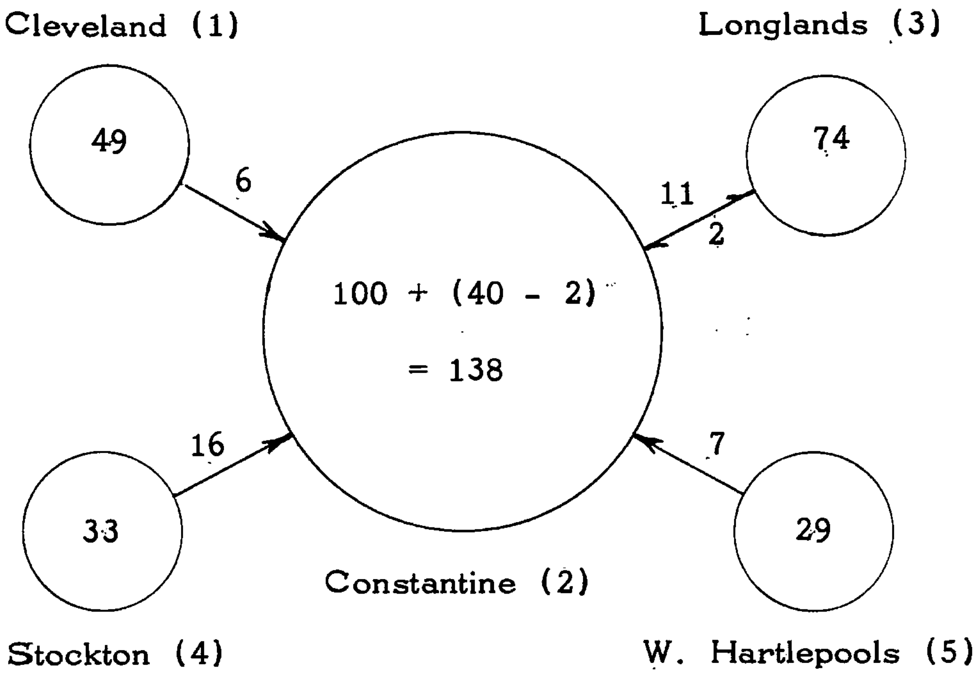
1. There is significant difference between areas at 5% but not at 1%.
2. There is no significant difference between years for the country as a whole.

The East Midlands is consistently below the mean value and Tees-side, with the exception of years 1960 and 1961, shows results below the mean. The high proportion of jobs in quality control may be an important factor in the low values for the Tees-side survey. The reasons for the low values in the East Midlands is unknown and investigation is outwith this survey. Further research into the National patterns may well form the basis of a future study.

Detailed inspection of results at Tees-side Colleges

(Appendix XX)

DIAGRAM 1



Returning to Diagram 1, an assessment of students passing from the contributory centres to the main centre Constantine can be made. Presenting the picture at its worst and over the six years of the survey, out of 185 students from the four contributory colleges only 40 (21.6%) reached the S3 year of the course (O.N.C. final year) at the main centre. However a satisfactory assessment must make allowance for those students who may have continued their studies beyond the limit of this survey and the following table shows the correction made in this respect.

TABLE XXIII

College	No. of students	No. of students who might continue their studies beyond this survey	No. of records known to be complete	No. passing S2	No. leaving the course after passing S2	No. entering S3 from S2 records known to be complete
1	49	10	39	10	4	6
2	28	2	26	13	2	11
3	74	6	68	26	15	11
4	33	6	27	20	4	16
5	29	10	19	7	-	7
	213	34	179	76	25	51

At the best therefore, only 28.5% of the students whose records were known to be complete entered the final year of the Ordinary National Certificate although 42.5% achieved success at S2 level. One-third of the successes did not continue and no college information was available giving reasons why students had withdrawn, nor had any effort been made to acquire follow-up information about the students and their careers.

Comparing these figures with those quoted in the report of the Central Advisory Council[44], the 42.5% success at S2 level in metallurgy was very close to the figure of 44% for all National Certificates although the "fall-out" in metallurgy was greater at 14% compared with 5% for all National Certificates and this was reflected in the number entering the S3 year - 28.5% in metallurgy compared with 39% for all National Certificates.

TABLE XXIV

College	No. of students entering S3	No. of students who might continue their studies beyond this survey	No. of records known to be complete	No. passing S3	No. leaving the course after passing S3	No. entering 1st Year HN from S3 records known to be complete
1	6	3	3	2	-	2
2	(11	1	10	9	-	9) 30
	(42*	6	36	23	2	21)
3	11	4	7	5	2	3
4	16	6	10	10	5	5
5	7	3	4	2	2	2
Total	93	24	70	51	9	42

* Direct entry and those who had reached the S3 year at the beginning of the survey.

On comparing the findings of Table XXIV with those of Crowther[45] it can be seen that the 73% gaining an Ordinary National Certificate in metallurgy was higher than the 67% shown for all National Certificates and the fall-out of 13% after gaining O.N.C. was considerably less than the 33% for all National Certificates.

The reversal in trends of the success or failure of the metallurgy students from that of the general pattern at S2 and S3 level may well stem from the fact that in the O.N.C. metallurgy course there was no study of metallurgy at the S1 and S2 level and that a considerable stimulus was given to the student's interest and effort once this study had begun at the S3 level.

Concluding this section of the investigation it is pertinent to examine the Higher National Certificate results and compare them with the general pattern.

TABLE XXV

College	No. of students entering A1	No. of students who might continue their study beyond this survey	No. of records known to be complete	No. passing A1	No. leaving course after passing A1	No. entering A2 from A1 records known to be complete
1	2	1	1	1	-	1
2	30	3	27	23	1	22) 37
	17●	-	17	17	2	15)
3	3	3	-	1*	-	-
4	5	1	4	4	1	3
5	2	1	1	1	-	1
Total	59	9	50	47	4	42

● Direct entry and those who had reached the A1 year at the beginning of the survey.

* Student successful but unknown whether he continued in A2.

The success rate at the A1 stage (Table XXV) again continued to be higher than that of the Crowther observations[45], 94% of students passing A1 compared with 78% in all National Certificates.

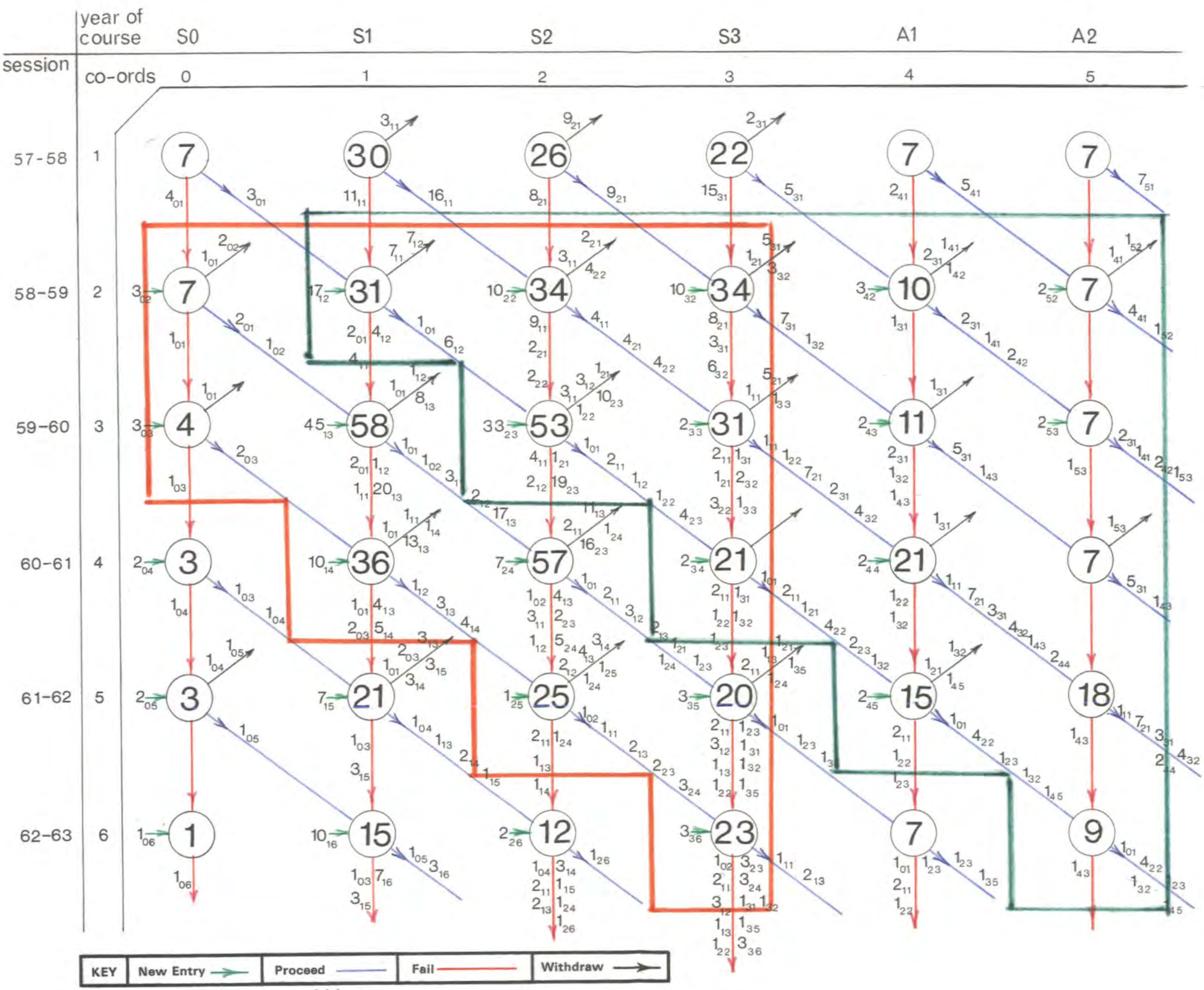
Finally Table XXVI shows the ultimate success of students entering the A2 year of the course. Again the success rate continued to be higher than that of the Crowther Report[45], 94% of the students entering the final year gaining H.N.C. compared with 77% for all National Certificates.

TABLE XXVI

College	No. of students entering A2	No. of students who might continue their study beyond this survey	No. of records known to be complete	No. passing A2
1	1	-	1	1
2	37 11*	1 -	36 11	35) 9) 44
3	-	-	-	-
4	3	-	3	3
5	1	-	1	1
Total	53	1	52	49

* Direct entry and those who had reached A2 year at the beginning of the survey.

From these tables and in terms of known completed records the successes in post-S2 years would appear to be most successful. However the grid (p. 111) presents a more complete picture in that it shows not



year of course
session
co-ords
S0
S1
S2
S3
A1
A2
0
1
2
3
4
5
57-58
58-59
59-60
60-61
61-62
62-63
KEY
New Entry
Proceed
Fail
Withdraw

only the successes at each stage of the course but those who had had to repeat a stage and the fall-out, and this indicated a much poorer examination success rate. Pooling the results over the six years of the survey it was possible to show the numbers moving on to the next stage of the course and by the co-ordinates to show the ultimate placing of a student from any year. From an inspection of the grid (p. 111) it was clear that the testing years were those of the Ordinary National Certificate and in particular at S2 and S3 level (see also Table XXVII).

Further investigation of the grid revealed a yet more disturbing result. Discounting the year 1957-58 since the total figures were an unknown composite of new entrants and students who were already at some stage of their study and examining the stepped area (Orange - ONC: Green - HNC) Tables XXVIII and XXIX show

TABLE XXVII

Stage	Number taking examination	Number passing to next stage	% Passing to next stage
S0	25	11	44
S1	191	71	37
S2	207	51	25
S3	151	44	29
A1	71	42	60
A2	55	49	89

the number of students who gained their ONC and for HNC without failure at any stage and this implies without failure in any subject at any stage.

TABLE XXVIII

Stage	Number of students	Number passing O.N.C. without failure
S0	6	-
S1	72	2
S2	51	4
S3	20	2
Total	149	8*

* Includes those who succeeded and withdrew after passing S3.

In effect only 5.4% of this total grouping gained an ONC without failure at any stage. Worse perhaps is the fact that only 8% of the entrants at S2 passed their Ordinary National Certificate without failure, since entry at this level would imply GCE '0' level passes or equivalent in chemistry, physics and mathematics.

TABLE XXIX

Stage	Number of students	Number passing H.N.C. without failure
S0	-	-
S1	17	-
S2	43	1
S3	14	-
A1	9	6
Total	83	7

Again within this grouping 8.4% gained HNC without failure in any subject or at any stage. The figure is inflated however by the success of entrants at A1 and if this figure was excluded from the survey only 1.3% of those entering the S1, S2 and S3 years gained HNC without failure in any subject or at any stage. These figures were considerably worse than those specified in the Crowther Report for National Certificates in Engineering[46].

From Table XXX it can be seen that a further 8% gained an Ordinary National Certificate after one extra year of study and only a further 0.7% after two extra years of study above that required to pass in the normal span of time of 4, 3, 2 or 1 year depending upon the entry point.

TABLE XXX

Stage	Number of students	No. passing ONC but having to repeat one year of the course	No. passing ONC but having to repeat two years of the course
S0	6	0	0
S1	72	2	0
S2	51	5	0
S3	20	5	1
Total	149	12	1

Table XXXI shows that a further 9.6% of the students gained their Higher National Certificate after one extra year of study and only 1.3% more after two extra years of study above that required to pass in the normal span of time for the course.

TABLE XXXI

Stage	Number of students	No. passing HNC but having to repeat one year of the course	No. passing HNC but having to repeat two years of the course
S0	-	-	-
S1	17	0	0
S2	43	4	0*
S3	14	4	1
A1	9	0	0
Total	83	8	1

* At the most two students who had failed S2 twice could have gained a Higher National Certificate but whose final results were not known since they were continuing to study beyond the period covered by this survey.

Another factor emerging from the grid (page 111) is the high rate of fall-out from the course. Out of a total of 216 students in the years S0, S1 and S2 138 (64%) of them withdrew before reaching the S3 year. No information was available about the subsequent studying or career or progress of the students who had withdrawn from the course. Such information becomes all the more important when it is realised that within the figure of 138 are 35 students who left the course after succeeding in their particular year, i.e. 10 at S1 and 25 at S2.

Turning now to an investigation of pass and failure rates in individual subjects and comparing these with the overall results the following table summarises data obtained from the grid (page111) and Appendix XXI.

TABLE XXXII

Stage	No. Examined	No. passing in each Examination						Overall Pass	
		Chemistry		Physics		Maths.			
		No.	%	No.	%	No.	%	No.	%
S1	191	96	50	96	50	108	56	74	35
S2	207	114	56	101	49	114	56	76	36
		Chemistry		Physics		Gen. Met.			
		No.	%	No.	%	No.	%	No.	%
S3	151	73	48	87	57	97	64	51	34
		Met.Anal.		Phys.Met.		Iron & Steel			
		No.	%	No.	%	No.	%	No.	%
A1	71	49	69	51	72	59	85	47	66
A2	55	49	89	50	90	51	92	48	88

The interesting facts that emerge from this table are:-

1. The low and almost exactly the same pass rate in the three years of the Ordinary National Certificate:

S1	35%
S2	36%
S3	34%

2. The narrow-banded pass rate in chemistry, physics and mathematics in the three years of the Ordinary National Certificate 48 - 57%.
3. The improved pass rate immediately a student began to study metallurgical subjects.
4. A substantially better pass rate at Higher National Certificate level.

Failure in any one of the three subjects taken in the National Certificate examination at one and the same sitting carried with it failure in the examination as a whole and required the student to repeat the entire stage of the course. (This is different from the Scottish Association for National Certificates and Diplomas where re-sits in the intermediate years and referments in the final years is permitted). It is relevant therefore to investigate failure rates by subjects and to compare them with the overall result. Failure by subject and combination of subjects is set out in table XXXIII.

If the re-sitting of one failed examination had been permissive and had all the candidates been successful then the overall pass rate would have been considerably improved.

Thus:-

S1	35% to 51%
S2	36% to 51%
S3	34% to 57%

TABLE XXXIII

Number failing in combinations of subjects and in separate subjects at each stage (pooling over all years of survey)

Stage	S1	S2	S3	A1	A2
Number of Candidates	191	207	151	71	55
Number failing in:-					
Chemistry, Physics, Maths.	60	60	-	-	-
Chemistry, Physics, Gen. Met.	-	-	32	-	-
Chemistry, Physics	20	22	20	-	-
Chemistry, Maths.	7	5	-	-	-
Chemistry, Gen. Met.	-	-	10	-	-
Physics, Maths.	8	14	-	-	-
Physics, Gen. Met.	-	-	2	-	-
Chemistry	8	6	16	-	-
Physics	7	10	10	-	-
Maths.	8	14	-	-	-
Gen. Met.	-	-	10	-	-
Met. Anal., Phys. Met., Iron & Steel	-	-	-	12	4
Met. Anal., Phys. Met.	-	-	-	5	0
Met. Anal., Iron & Steel	-	-	-	0	0
Phys. Met., Iron & Steel	-	-	-	1	0
Met. Anal.	-	-	-	5	2
Phys. Met.	-	-	-	2	1
Iron & Steel	-	-	-	0	0
Total Failures	117	131	100	24	7
Total Passes	74	76	51	47	48

A1 66% to 76%

A2 88% to 92%

The other factor worthy of note from Table XXXIII is the high and consistent failure in the combination of physics with chemistry at the S1, S2 and S3 stage. This is somewhat surprising since it could be argued that these two subjects would form the main core for metallurgical studies and ought therefore to receive closest attention both from a teaching and a learning point of view.

The technical college student does not like to work alone, nor indeed does he read his subject. He prefers a prescribed course of study in the form of detailed lecture notes and consistently objects to homework. To a lesser degree he is reluctant to take laboratory work seriously. The next part of the survey is concerned there fore with an examination of the relation of homework to theory examination marks and laboratory work to practical examination marks. The details of these correlations are set out in Appendix XXII along with other combinations of homework, theory, laboratory and practical work.

Examining first the homework and theory examination marks the following table summarises the position.

TABLE XXXIV

Homework v Theory

Stage: S1 — No. of students in sample = 191

No. failing in

	Physics				Chemistry				Maths		
	Hw.	Th.	Total		Hw.	Th.	Total		Hw.	Th.	Total
Hw.	4	27	31	Hw.	1	23	24	Hw.	6	30	36
Th.		62	62	Th.		66	66	Th.		55	55
Total	4	89	93	Total	1	89	90	Total	6	85	91

Stage: S2 — No. of students in sample = 207

No. failing in

	Physics				Chemistry				Maths		
	Hw.	Th.	Total		Hw.	Th.	Total		Hw.	Th.	Total
Hw.	3	15	18	Hw.	0	13	13	Hw.	5	22	27
Th.		78	78	Th.		55	55	Th.		51	51
Total	3	93	96	Total	0	68	68	Total	5	73	78

Stage: S3 — No. of students in sample = 151

No. failing in

	Physics				Chemistry				Gen. Met.		
	Hw.	Th.	Total		Hw.	Th.	Total		Hw.	Th.	Total
Hw.	0	10	10	Hw.	0	12	12	Hw.	0	11	11
Th.		46	46	Th.		61	61	Th.		39	39
Total	0	56	56	Total	0	73	73	Total	0	50	50

Stage: A1 — No. of students in sample = 71

No. failing in

	Physical Met.				Met. Analysis				Iron & Steel		
	Hw.	Th.	Total		Hw.	Th.	Total		Hw.	Th.	Total
Hw.	0	4	4	Hw.	0	4	4	Hw.	0	7	7
Th.		17	17	Th.		20	20	Th.		7	7
Total	0	21	21	Total	0	24	24	Total	0	14	14

Stage: A2 — No. of students in sample = 55

No. failing in

	Physical Met.				Met. Analysis				Iron & Steel		
	Hw.	Th.	Total		Hw.	Th.	Total		Hw.	Th.	Total
Hw.	0	2	2	Hw.	0	2	2	Hw.	0	1	1
Th.		3	3	Th.		4	4	Th.		3	3
Total	0	5	5	Total	0	6	6	Total	0	4	4

The most significant fact about this table is that very few students failed their course of study as a direct result of failing to gain 40% of the homework marks. Out of a total of 769 failures in the entire table only 19 students (2.4%) failed as a direct result of failure in homework. Conversely 567 (73%) failed as a direct result of the failure in the theory examination. These figures would suggest that passing in homework is not a guide to success in the examination. In turn, it may well be that the many factors that are associated with homework e.g. duration of exercise, style of question, freedom of the student to seek assistance and the method of marking, militate against homework being used to predict ultimate success in the examination.

TABLE XXXV

Laboratory work v Practical Examination

Stage: S1 No. of students in sample = 191

No. failing in

	Physics				Chemistry		
	Lw.	Pr.	Total		Lw.	Pr.	Total
Lw.	5	19	24	Lw.	4	16	20
Pr.		34	34	Pr.		39	39
Total	5	53	58	Total	4	55	59

Stage: S2 No. of students in sample = 207

No. failing in

	Physics				Chemistry		
	Lw.	Pr.	Total		Lw.	Pr.	Total
Lw.	2	15	17	Lw.	2	17	19
Pr.		34	34	Pr.		27	27
Total	2	49	51	Total	2	44	46

Stage: S3 No. of students in sample = 151

No. failing in

	Physics				Chemistry		
	Lw.	Pr.	Total		Lw.	Pr.	Total
Lw.	1	8	9	Lw.	0	14	14
Pr.		30	30	Pr.		17	17
Total	1	38	39	Total	0	31	31

Stage: A1 No. of students in sample = 71

No. failing in

	Physical Met.				Met. Analysis		
	Lw.	Pr.	Total		Lw.	Pr.	Total
Lw.	0	4	4	Lw.	1	4	5
Pr.		12	12	Pr.		9	9
Total	0	16	16	Total	1	13	14

Stage: A2 No. of students in sample = 55

No. failing in

	Physical Met.				Met. Analysis		
	Lw.	Pr.	Total		Lw.	Pr.	Total
Lw.	0	4	4	Lw.	0	1	1
Pr.		1	1	Pr.		5	5
Total	0	5	5	Total	0	6	6

Again, referring to Table XXXV, very few students failed their course of study as a direct result of failing in laboratory work - 4.8% while 64.3% failed in their practical examination. The reason for so very few failures as a direct result of failing in laboratory work may be due to the fact that students will often correct an exercise in the laboratory before writing the results in their laboratory note-book and thereby presenting only the corrected version for marking.

In support of the foregoing commentary a factorial analysis was made for each of the two subjects physics and chemistry at the S2 stage. The object was to study the inter-relations between component parts of a subject - the components being measured by the bands of marks in these parts and the analysis being that of the inter-correlation between the separate sets of marks.

Factorial Analysis

(A preliminary analysis was made in order to estimate the communality,* i.e. those figures which give a matrix of minimum rank and these figures are shown in the diagonal cells.)

Physics S2

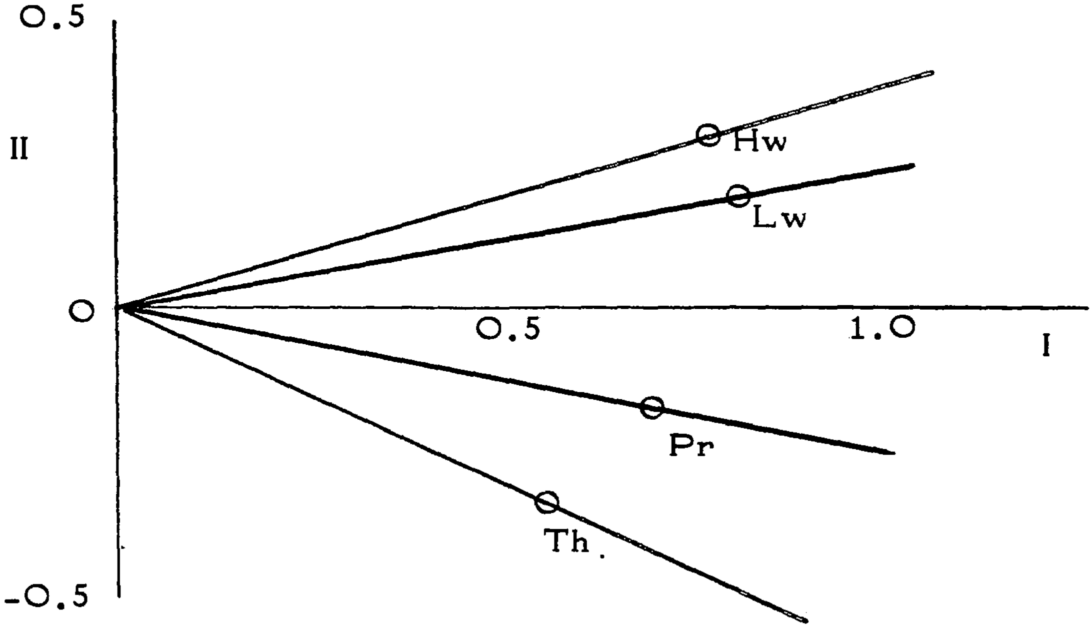
Table of Correlations

	Hw.	Lw.	Pr.	Th.				
Hw.	(.675)*	.668	.523	.308				
Lw.	.668	(.674)	.490	.413				
Pr.	.523	.490	(.521)	.445				
Th.	.308	.413	.445	(.441)				
	2.174	2.245	1.979	1.607	8.005	2.829	.353	
Factor I	.768	.794	.699	.568				
		.610	.537	.436	(.085)	.058	.014	.128
			.555	.451	.058	(.044)	.065	.038
				.397	.014	.065	(.032)	.048
					.128	.038	.048	.118
	Change signs 3 & 4			.981	.285	.205	.159	.332
Factor II					.288	.207	-.161	-.335

Summary of Analysis

	I	II	S1	S2	S3	S4
Hw.	.768	.288	.572			
Lw.	.794	.207		.572		
Pr.	.700	-.161			.696	
Th.	.568	-.335				.752

GRAPH A - PHYSICS S2



Chemistry S2

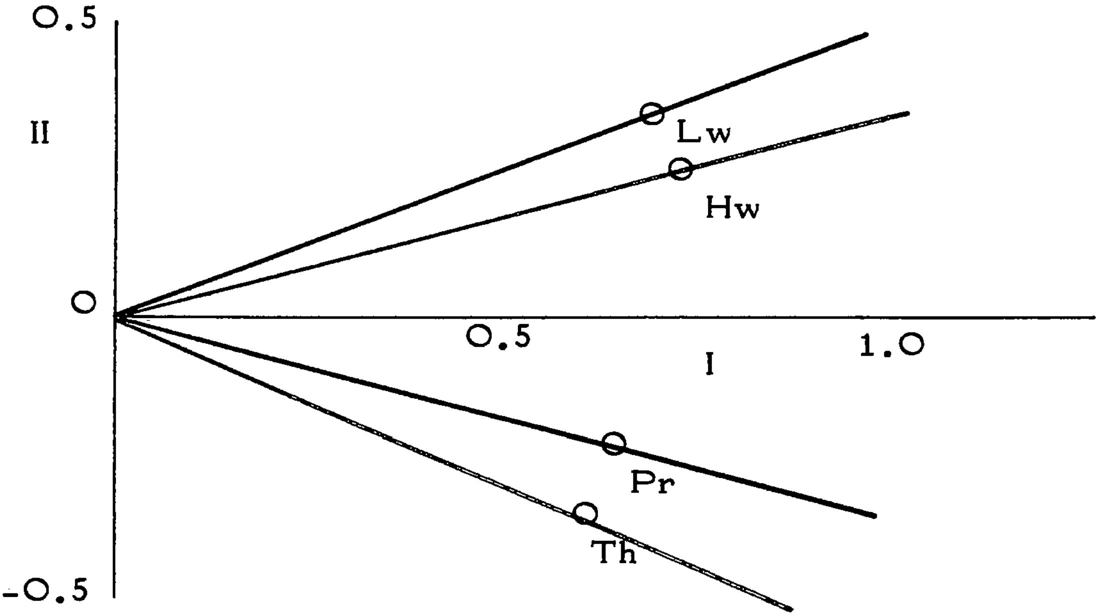
Table of Correlations

	Hw.	Lw.	Pr.	Th.				
Hw.	(.603)	.589	.402	.384				
Lw.	.589	(.603)	.408	.274				
Pr.	.402	.408	(.478)	.468				
Th.	.384	.274	.468	.479				
	1.978	1.874	1.756	1.605	7.213	2.686	.372	
Factor I	.736	.698	.654	.598				
		.514	.482	.440	(.061)	.075	.080	.056
			.456	.417	.075	(.116)	.048	.143
				.391	.080	.048	(.051)	.077
					.056	.143	.077	(.122
Change signs 3 & 4				1.308	.272	.382	.256	.398
Factor II					.239	.334	-.224	-.348

Summary of Analysis

	I	II	S1	S2	S3	S4
Hw.	.736	.239	.632			
Lw.	.698	.334		.633		
Pr.	.654	-.224			.723	
Th.	.598	-.348				.722

GRAPH B - CHEMISTRY S2



The point of interest that emerges from this analysis is the close linkage between homework and laboratory work on the one hand, both for physics and chemistry and that between practical and theory examination on the other. There is a sharp separation between these two pairs. This is shown in graphs A and B.

Following upon this investigation it was considered important to make a correlation study to examine agreement between various component marks of the ONC/HNC course. The components were Homework, Laboratory work, Theory examination and Practical examination. The supplementary correlation tables with the calculated value of r are set out in Appendix XXIII. The following table is an example of the investigation of Physics S2 Homework v Theory followed by the calculation of r.

<u>Theory</u>

				14	30	49	41	46
		1	2	3	4	5	6	17
Hw.	6	-	1	1	5	3	3	10
	5	13	7	15	13	13	1	
	4	22	4	16	8	6	1	
	3	25	6	10	8	8	-	
	2	3	-	2	-	-	-	
	1	12	-	1	-	-	-	

Calculation used in determining Correlation Value r

S2 Physics Homework v Laboratory work

Marginal Distribution

Homework

f	x	fx	fx^2
13	+2	26	52
62	+1	62	62
57	0	88	0
57	-1	-57	57
5	-2	-10	20
13	-3	-39	117
		-106	308

$\sum fx = -18$

$$A = \sum fx^2 - \frac{(\sum fx)^2}{n}$$

$$= 308 - \frac{324}{207}$$

$$= 306.43$$

Laboratory work

f	x	fx	fx^2
16	+2	32	64
78	+1	78	78
49	0	110	0
47	-1	-47	47
4	-2	-8	16
13	-3	-39	117
		-94	322

$\sum fx = +16$

$$B = \sum fx^2 - \frac{(\sum fx)^2}{n}$$

$$= 322 - \frac{256}{207}$$

$$= 320.76$$

Diagonal Distribution Homework/Laboratory work

f	x	fx	fx^2
2	+3	6	18
8	+2	16	32
31	+1	31	31
98	0	53	0
53	-1	-53	53
11	-2	-22	44
4	-3	-12	36
		-87	214

$$\sum fx = -34$$

$$D = \sum fx^2 - \frac{(\sum fx)^2}{n}$$

$$= 214 - \frac{1156}{207} = \underline{\underline{208.41}}$$

$$r = \frac{A + B - D}{2\sqrt{A.B}} = \frac{306.43 + 320.76 - 208.41}{2\sqrt{306.43 \times 320.76}}$$

$$= \frac{418.78}{627.02} = \underline{\underline{0.668}}$$

The following table summarises the correlation coefficient 'r' for the various components of a given subject and for the various subjects of the same components. The correlation coefficient calculations were made by use of a computer programme.

TABLE XXXVI

Stage	Component	r	Stage	Component	r
S2 Physics	Hw - Th	0.308	S1 Physics	Hw - Th	0.388
	Lw - Pr	0.490	S2 Physics	Hw - Th	0.308
	Hw - Lw	0.668	S3 Physics	Hw - Th	0.351
	Hw - Pr	0.523	S1 Chemistry	Hw - Th	0.358
	Lw - Th	0.413	S2 Chemistry	Hw - Th	0.384
	Pr - Th	0.445	S3 Chemistry	Hw - Th	0.360
S2 Chemistry	Hw - Th	0.384	S3 Gen Met	Hw - Th	0.418
	Lw - Pr	0.408	A1 Phys Met	Hw - Th	0.580
	Hw - Lw	0.589	A2 Phys Met	Hw - Th	0.440
	Hw - Pr	0.402	A1 Met Anal	Hw - Th	0.458
	Lw - Th	0.274	A2 Met Anal	Hw - Th	0.481
	Pr - Th	0.468	A1 Iron & Steel	Hw - Th	0.724
S2 Between	Phys - Chem	0.624	A2 Iron & Steel	Hw - Th	0.439
Subjects	Maths- Phys	0.514	S1 Physics	Lw - Pr	0.489
	Chem - Maths	0.429	Chemistry	Lw - Pr	0.384
S1 Maths	Hw - Th	0.427	S2 Physics	Lw - Pr	0.490
S2 Maths	Hw - Th	0.457	Chemistry	Lw - Pr	0.408
S3 Physics	Lw - Pr	0.336	A2 Phys Met	Lw - Pr	0.372
Chemistry	Lw - Pr	0.486	Met Anal	Lw - Pr	0.325
A1 Phys Met	Lw - Pr	0.583			
Met Anal	Lw - Pr	0.306			

Ordinary National Correlations

Homework - Theory Examination Correlation

Stage	N	Maths	Physics	Chemistry
S1	191	0.427	0.388	0.358
S2	207	0.457	0.308	0.384
S3	151		0.351	0.360

It appears that there is no great variation in the size of the correlation within subjects. The largest difference of variation is 0.308 to 0.388 in respect of Physics. The following test was applied to see whether the three Physics correlations can be regarded as homogeneous.

r_i	z_i	$n_i - 3$	$(n_i - 3)z_i$	$(n_i - 3)z_i^2$
0.388	0.409	188	76.892	31.449
0.308	0.319	204	65.076	20.759
0.351	0.367	148	54.316	19.934
Total	-	540	196.284	72.142

$$\chi^2 = 72.142 - 71.347 = \underline{\underline{0.79}} \text{ (d.f. = 1)}$$

and this value is not significant.

The Physics correlations can be regarded therefore as being homogeneous, i.e. as a random sample from one and the same population. The same is true in respect of the other two subjects. Pooling (or averaging) the correlations by the z-procedure. The results are:-

N	Maths	Physics	Chemistry
549	z = 0.476	z = 0.363	z = 0.387
	r = 0.443	r = 0.348	r = 0.369

Subject Correlations for Homework and Theory

It is now of interest to see whether there is any statistical significant difference between subjects in the average value of the correlation - Homework and Theory. Taking the extreme values 0.443 and 0.348 for Mathematics and Physics:-

Difference in z value = 0.476 - 0.363 = 0.113

Standard error of this difference $= \sqrt{\frac{2}{546}} = \sqrt{\frac{1}{273}} = \underline{\underline{0.0605}}$

The difference is not quite statistically significant at 5% level.

Higher National Correlations

Homework and Theory Correlations

Stage	N	Iron & Steel	Phys Met	Met Anal
A1	71	0.724	0.580	0.458
A2	55	0.439	0.440	0.481

It is first relevant to see whether the rather large difference between the Iron & Steel correlations 0.724 and 0.439 is statistically significant.

r_i	z_i	$n_i - 3$	$(n_i - 3)z_i$	$(n_i - 3)z_i^2$
0.724	0.916	68	62.3	57.06
0.439	0.471	52	24.5	11.54
Total		120	86.8	68.6

$$\chi^2 = 68.6 - \frac{86.8^2}{120} = 68.6 - 62.79 = 5.81 \quad (\text{d.f.} = 1)$$

It follows therefore that 0.724 and 0.439 can scarcely be regarded as random samples from one and the same population. The high correlation for Iron & Steel Manufacture may well be a function of the way the syllabus is split up between the A1 and A2 years. At the A1 stage it has been the practice to confine study to iron manufacture, much of which is highly descriptive. The type of Theory examination therefore may have followed a close pattern to that of the homework set. At the A2 level the student is concerned not only with the description of steel making processes but with the need to understand the physico-chemical fundamentals of the processes. The mathematical concept of the thermodynamics of metal extraction seems to create difficulties for the students mainly because of deficiencies in mathematics. These two factors may well be responsible for the statistical differences at A1 and A2 level. Concerning the correlations within and between the other pairs of subjects no statistically significant differences are apparent. The mean correlation in respect of Physical Metallurgy is 0.523 and that in respect of Metallurgical Analysis 0.468.

Correlation Between Successive Years (Theory only)

This section is concerned with the progress of students from one year to the next, i.e. whether a student who passed one stage of the course passed or failed the next stage and whether his level of pass was as good as that in the previous year. This information is summarised in Table XXXVII which is abstracted from Appendix XXIV.

TABLE XXXVII

Physics

S1 - S2		S2 Bands Fail 1	2	Pass 3	4	5	6	Proportion falling into a lower band on 2nd occasion
	6	-	-	-	-	1	-	1/1
S1 Bands	5	9	1	8	5	2	1	23/26
Pass	4	4	3	4	4	4	-	11/19
	3	7	1	1	3	-	-	8/12
Total		25		34				43/59 = 73%

% failing on 2nd occasion = 42%

Chemistry

S1 - S2		S2 Bands Fail 1	2	Pass 3	4	5	6	Proportion falling into a lower band on 2nd occasion
	6	-	-	1	-	1	1	2/3
S1 Bands	5	3	3	8	6	10	-	20/30
Pass	4	6	-	8	-	-	-	14/14
	3	7	-	2	3	-	-	7/12
Total		19		40				43/59 = 73%

% failing on 2nd occasion = 32%

TABLE XXXVII (Contd.)

Maths

S1 - S2		S2 Bands Fail 1	2	Pass 3	4	5	6	Proportion falling into a lower band on 2nd occasion
	6	1	1	-	-	1	-	3/3
S1 Bands	5	6	1	3	4	4	-	14/18
Pass	4	4	-	1	5	1	-	5/11
	3	13	3	6	4	1	-	16/27
Total		29		30				38/59 = 64%

% failing on 2nd occasion = 51%

Physics

S2 - S3		S3 Bands Fail 1	2	Pass 3	4	5	6	Proportion falling into a lower band on 2nd occasion
	6	-	-	1	-	1	-	2/2
S2 Bands	5	3	1	3	5	1	-	12/13
Pass	4	10	3	2	4	2	-	15/21
	3	4	0	5	5	2	-	4/16
Total		21		31				33/52 = 63%

% failing on 2nd occasion = 40%

Chemistry

S2 - S3		S3 Bands Fail 1	2	Pass 3	4	5	6	Proportion falling into a lower band on 2nd occasion
	6	1	-	-	-	1	-	2/2
S2 Bands	5	3	1	5	4	3	-	13/16
Pass	4	5	2	1	-	-	1	8/9
	3	9	2	7	6	1	-	11/25
Total		23		29				34/52 = 65%

% failing on 2nd occasion = 44%

Physical Metallurgy

A1 - A2		A2 Bands Fail 1	2	Pass 3	4	5	6	Proportion falling into a lower band on 2nd occasion
	6	-	-	-	-	1	-	1/1
A1 Bands	5	1	-	1	1	4	-	3/7
Pass	4	-	1	9	9	1	-	10/20
	3	-	-	6	3	1	-	0/10
Total		2		36				14/38 = 37%

% failing on 2nd occasion = 5%

Metallurgical Analysis

A1 - A2		A2 Bands: Fail 1	Fail 2	Pass 3	Pass 4	Pass 5	Pass 6	Proportion falling into a lower band on 2nd occasion
A1 Bands Pass	6	-	-	-	1	-	-	1/1
	5	1	1	3	5	5	-	10/15
	4	-	-	-	6	1	-	0/7
	3	-	1	5	7	2	-	1/15
Total		3		35				11/38 = 29%

% failing on 2nd occasion = 4%

Iron & Steel

A1 - A2		A2 Bands: Fail 1	Fail 2	Pass 3	Pass 4	Pass 5	Pass 6	Proportion falling into a lower band on 2nd occasion
A1 Bands Pass	6	-	-	-	-	-	-	-
	5	-	-	4	3	5	-	7/12
	4	-	-	2	7	7	-	2/16
	3	1	-	3	6	-	-	1/10
Total		1		37				10/38 = 27%

% failing on 2nd occasion = 3%

These tables show:

1. That most students in the Ordinary National Certificate course obtain a rating in the next stage of the course that was lower than in the previous stage.
2. That the proportion gaining a lower grading was consistently lower in the Ordinary National Certificate, i.e. between 63% and 73%.
3. In the Higher National Certificate course a minority of the students obtained a rating in the next stage of the course that was lower than in the previous stage.
4. That the proportion gaining a lower grading was consistently lower 27% - 37%.
5. The number failing the next stage is consistently small 3% - 5%.

To investigate improvement (or worsening) performance in respect of re-sit candidates

Following on the previous investigation it was a natural step to consider how re-sit candidates succeeded in the examinations they repeated. A summary of Appendix XXV is set out in the following table.

TABLE XXXVIII

S1. Physics

	2nd Attempt					3rd Attempt		
		F	P	Total			F	P	Total
1st Attempt	P	7	13	20	2nd Attempt	P	2	3	5
	F	23	16	39		F	2	3	5
	Total	30	29	59		Total	4	6	10

S1. Chemistry

	2nd Attempt					3rd Attempt			
		F	P	Total			F	P	Total
1st Attempt	P	9	9	18	2nd Attempt	P	2	2	4
	F	22	19	41		F	3	3	6
	Total	31	28	59		Total	5	5	10

S1. Maths

	2nd Attempt					3rd Attempt			
		F	P	Total			F	P	Total
1st Attempt	P	5	15	20	2nd Attempt	P	0	4	4
	F	24	14	38		F	3	3	6
	Total	29	29	58		Total	3	7	10

S2. Physics

	2nd Attempt					3rd Attempt			
		F	P	Total			F	P	Total
1st Attempt	P	7	14	21	2nd Attempt	P	0	1	1
	F	20	23	43		F	5	6	11
	Total	27	37	64		Total	5	7	12

TABLE XXXVIII (Contd.)

S2. Chemistry

		2nd Attempt					3rd Attempt		
		F	P	Total			F	P	Total
1st Attempt	P	6	22	28	2nd Attempt	P	0	4	4
	F	17	19	36		F	4	4	8
	Total	23	41	64		Total	4	8	12

S2. Maths

		2nd Attempt					3rd Attempt		
		F	P	Total			F	P	Total
1st Attempt	P	6	18	24	2nd Attempt	P	3	6	9
	F	11	29	40		F	1	2	3
	Total	17	47	64		Total	4	8	12

S3. Physics

		2nd Attempt					3rd Attempt		
		F	P	Total			F	P	Total
1st Attempt	P	5	25	30	2nd Attempt	P	2	3	5
	F	12	12	24		F	2	2	4
	Total	17	37	54		Total	4	5	9

S3. Chemistry

		2nd Attempt					3rd Attempt		
		F	P	Total			F	P	Total
1st Attempt	P	3	15	18	2nd Attempt	P	2	4	6
	F	16	20	36		F	3	0	3
	Total	19	35	54		Total	5	4	9

TABLE XXXVIII (Contd.)

S3. General Metallurgy

	2nd Attempt					3rd Attempt			
		F	P	Total			F	P	Total
1st Attempt	P	5	21	26	2nd Attempt	P	1	1	2
	F	12	16	28		F	1	6	7
	Total	17	37	54		Total	2	7	9

A1. Physical Metallurgy

	2nd Attempt					3rd Attempt			
		F	P	Total			F	P	Total
1st Attempt	P	0	5	5	2nd Attempt	P	0	0	0
	F	4	4	8		F	0	1	1
	Total	4	9	13		Total	0	1	1

A1. Metallurgical Analysis

	2nd Attempt					3rd Attempt			
		F	P	Total			F	P	Total
1st Attempt	P	1	3	4	2nd Attempt	P	0	0	0
	F	5	4	9		F	0	1	1
	Total	6	7	13		Total	0	1	1

A1. Iron & Steel

	2nd Attempt					3rd Attempt			
		F	P	Total			F	P	Total
1st Attempt	P	1	7	8	2nd Attempt	P	0	0	0
	F	2	3	5		F	0	1	1
	Total	3	10	13		Total	0	1	1

From these tables the percentage increase (or decrease) in success was calculated.

TABLE XXXIX

Stage	Subject	% increase in No. of passes	
		1st to 2nd Attempt	2nd to 3rd Attempt
S1	Physics	16	10
	Chemistry	17	10
	Mathematics	16	30
S2	Physics	26	50
	Chemistry	20	43
	Mathematics	32	- 8
S3	Physics	12	0
	Chemistry	32	-67
	General Met.	21	55
A1	Physical Met.	31	
	Met. Analysis	23	
	Iron & Steel	17	

The table shows a general pattern of increase both at 2nd attempt and 3rd attempt, although the 2nd to 3rd attempt samples were small and the increases erratic. In the 1st to 2nd attempt all showed improvement with a 12% to 32% increase, the mean being 22%. For this group of students the results would indicate that a greater period of time is necessary to assimulate their course of study.

<u>To examine success rates in terms of the number of Science subjects (Chemistry, Physics and Mathematics) gained at 'O' level G.C.E.</u>

Appendix XXVI presents these results in detail and Table XL summarises the selected information to calculate the values of $^{C}/_{A}$ and $^{C}/_{B}$.

TABLE XL

Stage	Passing in	No. of students A	No. who might continue to study	No. of completed records B	No. passing S2 C	C/A	C/B
S0 to S2	MCP	44	7	37	24	0.545	0.648
	MC	13	3	10	2	0.154	0.200
	CP	12	1	11	6	0.500	0.545
	MP	19	3	16	10	0.526	0.625
	M	19	4	15	7	0.368	0.467
	C	8	2	6	3	0.375	0.500
	P	2	-	2	1	0.500	0.500
	None	96	14	82	23	0.240	0.280
S3	MCP	36	6	30	24	0.667	0.800
	MC	3	1	3	3	1.000	1.000
	CP	7	1	6	4	0.571	0.667
	MP	8	2	6	3	0.375	0.500
	M	9	3	6	5	0.556	0.833
	C	4	2	2	2	0.500	1.00
	P	1	-	1	1	1.000	1.00
	None	25	8	17	9	0.360	0.530
A1	MCP	29	4	25	21	0.724	0.840
	MC	4	2	3	3	0.750	1.000
	CP	7	1	6	6	0.857	1.000
	MP	2	-	2	2	1.000	1.000
	M	2	-	2	2	1.000	1.000
	C	2	-	2	2	1.000	1.000
	P	2	-	2	2	1.000	1.000
	None	11	2	9	1	0.091	0.111
A2	MCP	26	-	26	26	1.000	1.000
	MC	4	-	4	4	1.000	1.000
	CP	7	-	7	7	1.000	1.000
	MP	2	-	2	2	1.000	1.000
	M	1	-	1	1	1.000	1.000
	C	2	-	2	2	1.000	1.000
	P	1	-	1	1	1.000	1.000
	None	10	1	9	6	0.600	.644

Both the ratios follow much the same pattern. Listing the subjects and subject combinations in order of the size of the proportion $C/_B$ the following results (Table XLI) were obtained.

TABLE XLI

	ORDERING							
Stage	1	2	3	4	5	6	7	8
S2	MCP	MP	CP	P	= C	M	None	MC
S3	MC	= C	= P	M	MCP	CP	None	MP
A1	MP	= MC	= CP	= M	= C	= P	MCP	None
A2	MCP	= MC	= CP	= MP	= M	= C	= P	None

(1) The proportion of students with no 'O' levels who passed at each stage of the examination was consistently below the proportions for students with one or more 'O' level passes and this was true for all stages.

(2) There does not appear to be any clear cut division between the ordering and the number of 'O' levels gained. It should be noted however that although the ordering of 'MCP' at S3 and A1 is low down the list the proportion is nevertheless high and since the 'MCP' grouping involves more students in the sample than most of the other groupings it may be given a fairly high rating in terms of success.

(3) In general, of the students who had only one 'O' level science subject those with physics did better than those with chemistry or mathematics. In fact the ordering of these science 'O' levels appears to be the same as the order of the g-factor loadings obtained in the Factor Analysis, i.e. Physics, Chemistry and Mathematics.

The investigations made in this chapter suggest that much greater thought must be given to selection, to the integration of education with the industrial need and in bringing a sense of educational realism to the student. These are issues that will receive attention in the following chapters.

Chapter III

Student appraisal of the National Certificate Course in Metallurgy.

The examination of student records in the previous chapter revealed a high rate of failure and a high rate of fall-out, particularly in the Ordinary National Certificate years. These results were the end-product of schemes of work (Appendix XI) devised by the professional metallurgist and educators. In an attempt therefore to diagnose the cause of failure it was not unreasonable to inquire of the students how they assessed their course of study and what was its effect upon their industrial careers.

Questionnaire and interviewing techniques were used to determine student reaction but before this is discussed in detail it is important to consider the background and traditions of the Tees-side industries.

In Britain, industry has developed either on a coal-field or close to a navigable estuary, and although Tees-side falls into the latter category it is doubtful whether other industrial concentrations have had the advantages of Tees-side. The area has enjoyed a unique position with carboniferous rocks of Northumberland and Durham providing coal and limestone, the Triassic rocks of the centre region containing important deposits of salt and anhydrite and in the past the South and East have provided considerable quantities of Jurassic iron ore.

Blast furnaces were existent in the North Riding of Yorkshire as long ago as 1570 and three and a half centuries ago the Cleveland district was the only centre of one of the few branches of the then chemical industry. At that time alum manufacture was a monopoly of the Pope. The young Sir Thomas Chaloner succeeded in gaining entry to the work at Puteoli where he noticed marked similarity of the surrounding vegetation to that of some parts of the Guisborough estate. With commendable astuteness he deduced he would find alum at Guisborough too, and indeed he did. For this and for smuggling home Italian key labour he was excommunicated from the Church.

Later the prosperity of the alum working proved too tempting for Charles I to resist and it is sufficient to say he was responsible for nationalising the industry. These examples serve to show the long history of metallurgical and chemical activities indigenous in the Tees-side area and it is against this background that the highly developed industrial community can be examined.

Tees-side comprises 9% of the area of the North East of England and 0.5% of Great Britain. In 1957 at the beginning of this survey its population was 607,000 (21% of the North East population and 1.2% of the National total). Within the framework of Tees-side the population density was more than double the National average of 564. It is more significant to note that the central administration districts of Tees-side form a conurbation of more than half the total (i.e. 342,000) and yet was smaller than the conurbation of Sheffield [47]. In spite of this and in spite of the fact that the ironstone mines of Cleveland are no longer worked, Tees-side in producing something of the order of 20% of the Nation's steel was the second largest producing region after South Wales. Of the 128,000 workers [48] in the manufacturing industries, 79,000 are engaged in the metal manufacturing and engineering trades and a further 23,000 are engaged in chemical manufacture. With the emphasis on these two basic industries it is not surprising that not only the individual firms but even the industries themselves were prepared to vie with one another for the best labour force. To the young worker entering upon his first job the choice may well have been between either the modern unit process chemical plant of Imperial Chemical Industries, Wilton with its sophisticated analytical methods and research potential or the grimy iron and steel plant at Skinningrove with a career in quality control and operating in a sparsely equipped laboratory. Further, the study content of the early years of vocational education must have seemed to be more realistic to the young chemist than to the metallurgist for each were following a common curriculum of chemistry, physics and mathematics and within the period of the survey and without exception taught by specialists who had not been involved in the metallurgical industry. Again the danger hazards of a metallurgical plant and the possibilities of shift working were factors which influenced a young man's choice, if not directly, then by the concern and influence of the parent. With these factors in mind it can be appreciated why so many entrants to the chemical industry and therefore to the National Certificate in Chemistry had a greater number of GCE '0' levels than those entering the iron and steel industry (Appendix I). At the same time it should be noted that some young men entered the iron and steel industry because of a deep sense of loyalty to family tradition.

Consequent upon this arbitary selection before students entered the college, no other selection procedure was made by the colleges save that provided in the regulations of the Joint Committee, namely the entry to a particular year of the course by virtue of GCE '0' or 'A' level passes in the right group of subjects[49].

It was important therefore to find out why students elected to work in the iron and steel industry and to learn something about their thoughts on the National Certificate course in Metallurgy. To obtain this information it was decided to ask the group of students representing one year's total population from the five Tees-side colleges, students selected from all levels of the Ordinary and Higher National Certificate course to complete a questionnaire. This was followed up by a personal interview of a random sample of one in every five who had completed the questionnaire. The first task was to make a preliminary investigation on students from another area, an area that could provide a sample, numerically of the same order as Tees-side and an area that could provide similar job specifications for the young entrant. Ideally it would have been desirable to select an area that subscribed to the same course of study and the same examinations but this was not possible. To approach these requirements as close as possible it was decided to select the Coatbridge district of Lanarkshire where (a) the industry, like that of Tees-side, was concerned with the manufacture of plate, heavy and light sections and bars and (b) the standards of the two National Certificate schemes approximate to one another.

The first run of the questionnaire was made on an 0.2. Ordinary National Certificate group (equivalent to S3 nomenclature of Chapter II) of eighteen students and after certain modifications to remove ambiguities and to simplify complex questions, the questionnaire was given to the total population of Coatbridge Technical College. It was considered that a comparison between the two areas might shed light on some of the issues to be discussed. The same questionnaire was given to the Tees-side population within the five colleges. In order to standardise as closely as possible on the two areas the questionnaires were answered in the presence of a lecturer in the colleges but who was asked not to discuss the questions with the students.

The one hundred and eleven questionnaires from the five Tees-side colleges and eighty questionnaires from Coatbridge Technical College represents the total population of students from the two areas studying at the same time.

Appendix XXVII shows a typical questionnaire with answers representative of the majority of students from Tees-side and Appendix XXVIII shows the results of the answers to all questionnaires.

The questionnaire was designed to examine

(1 General problems associated with work and study and

(2) specific issues of course content.

These two areas of investigation refer to questions 2 - 9 and question 10 respectively.

The results of the questionnaires will be discussed under these two headings and Table XLII summarises the answers to questions 2 - 9 (a) for the total population of the two areas and (b) for those students who were interviewed subsequent to completing the questionnaires.

TABLE XLII

	Tees-side Population Total	Tees-side Population Interviewed	Coatbridge Population Total	Coatbridge Population Interviewed
Total No. of questionnaires:	111	25	80	15
No. & nature of replies to:				
Q2 Type of School:				
Modern	14	4	1	
Technical	8	3	8	1
Grammar	86	18	64	12
Comprehensive	-	-	2	1
Public	3	-	5	1
Q3 Passes at GCE or SCE '0' level 0	28	5	5	-
1	5	2	4	-
2	11	4	8	-
3	12	4	3	-
4	11	3	9	2
5+	44	7	31	13
Q4 Nature of Job:				
Quality Control	84	18	60	9
Eng. Application	12	2	6	1
Research/Dev.	15	5	14	5
Q5 Job Selection:				
(a) Whilst at school	51	13	55	11
(b) Advised by YEO	11	3	3	-
(c) Parent's wish	6	2	4	-
(d) Only job available	43	7	18	4
Q6 Shift Working: Yes	67	12	32	5
No	44	13	48	10
6A Interfering with study:				
Yes	34	9	13	3
No	33	3	19	2
6B College provision to help shift working: Yes	38	6	-	-
No	29	6	32	5

TABLE XLII (cont'd)

		Tees-side Population		Coatbridge Population	
		Total	Interviewed	Total	Interviewe
Q7 Preference for Metallurgy at an early stage:	Yes	107	25	76	15
	No	4	-	3	-
Q8 Course too academic	Yes	50	13	55	10
	No	61	12	25	5
All students					
ONC students only:	Yes	45	14	9	7
	No	17	6	1	1
Q9 Enough time for study:	Yes	38	8	45	6
	No	73	17	35	9

Before inspecting the answers to the questionnaire it will be helpful to compare the English system of secondary education with that of the Scottish system. Points of similarity and points of difference will help to bring a greater understanding to the answers that were received from the two areas.

1. The Scottish system of the Junior Secondary and Senior Secondary School equate very closely to the Modern and Grammar School

of the English system.

2. The transfer to secondary education takes place at the age of 12+ in Scotland. In England transfer takes place at 11+.

3. In Scotland students take the Scottish Certificate of Education '0' level examinations and these are of a similar standard to the General Certificate of Education '0' level examinations in the English system.

4. In the Senior Secondary School students take their SCE "Highers" one year after their '0' levels. At this stage a greater number of subjects are studied in breadth than in the English "Advanced" levels and which are normally of two years duration.

5. A greater proportion of students attend Senior Secondary Schools in Scotland than attend Grammar Schools in England.

Type of School and the number of '0' level passes gained by students.

TABLE XLIII

Type of School attended by students	In Questionnaires from Tees-side	In Questionnaires from Coatbridge	In Tees-side Records Ch.II
	%	%	%
Modern - Jnr.Sec.+	13	2	12
Technical	7	10	9
Grammar - Sen.Sec.+	77	80	79
Comprehensive	-	2	-
Public - Private +	3	6	-

+ Scottish System

Table XLIII shows the distribution of students between the various schools for the two areas and compares the answers to the questionnaires with the results of the examination of the Tees-side records for the six years of the survey. The percentage distribution would suggest that the school provision in the two areas was very similar and that the samples followed very closely to the sample of the 285 Tees-side students whose records were examined in Chapter II.

In making comparisons between the two systems it must be remembered that for a student to enter the S2 (01) year of the Ordinary National Certificate course (England) he must have '0' level passes in chemistry, physics, mathematics and English language. In the Scottish system three '0' level passes only are required to gain entry to the S2 (01) year. These are chemistry, physics and mathematics.

TABLE XLIV

No. of '0' levels gained	by students answering questionnaire: Tees-side	Coatbridge	By students in Tees-side Records Ch.I
	%	%	%
0	25	6	27
1	5	5	5
2	10	10	10
3	10	4	12
4	10	11	12
5+	40	64	34

Table XLIV shows the number of '0' levels gained by students in the two areas and although it can be seen that 50% of the Tees-side students who answered the questionnaire gained 4 or more '0' level passes only 23% had the right kind of passes to enter S2 (01) year of the course. This was significantly different from the Scottish system where 79% of the students had 3 or more '0' levels (entry to S2 (01) year and 75% were of the right kind to enter the 01 year.

In interviewing the students 11 of the secondary modern schoolboys considered themselves to be in a disadvantageous position when compared with the grammar schoolboys and 3 students who had reached the S2 (01) stage with marginal passes and who had failed at the first attempt both at S0 and S1 years said they were unable to cope with the situation and intended to withdraw from the course. The other two modern schoolboys were quite confident and have since gained their Higher National Certificates. The general opinion amongst technical schoolboys was that they were attracted to the practical work while the grammar school entrants felt that more application could have been given to their science teaching while they were at school.

Type of Job

Referring to Table XVII, Chapter II it will be seen that two firms Dorman Long & Co., Ltd., and South Durham Steel & Iron Co., Ltd., accounted for 71% of the student load. These two Companies were the two main employers of personnel in the Quality Control and Research and Development kind of jobs.

Table XLV shows the distribution of students in the three categories and compares the answers to the questionnaire with the results of the examination of the Tees-side records for the six years of the survey, Chapter II.

TABLE XLV

Type of Job	% of students answering questionnaire: Tees-side	Coatbridge	% of students in Tees-side Records Ch.II
Quality Control	76	75	78
Eng. Application	10	7	9
Research/Dev.	14	18	13

There is a close similarity in distribution between the type of jobs in the two areas with the emphasis on quality control. Continuing this part of the investigation on lines similar to those used for the examination of student records (Chapter II), the next stage was to compare the type of job with the number of '0' levels gained at school. This information is summarised in Table XLVI and the graph diagrams show the distribution for each grouping in each of the three types of job.

TABLE XLVI

Type of Job	Group	% of students gaining the following No. of '0' levels SCE/GCE 0	1	2	3	4	5+
Quality Control	Questionnaire:						
	Tees-side	29	4	11	12	11	33
	Coatbridge	8	7	13	3	7	62
	Student Records (Ch.II)						
	Tees-side	29	6	11	14	13	27
Eng. App.	Questionnaire:						
	Tees-side	25	17	-	17	8	33
	Coatbridge	-	-	-	17	50	33
	Student Records (Ch.II)						
	Tees-side	40	8	4	12	8	28
Research and Dev.	Questionnaire						
	Tees-side	7	-	13	-	7	73
	Coatbridge	-	-	-	-	14	86
	Student Records (Ch.II)						
	Tees-side	7	-	10	5	7	71

In each case the answers to the Tees-side questionnaire group follows very closely to the pattern of the Tees-side student records over the whole survey. The graphs show that a greater percentage of the Coatbridge group had 4 and 5+ '0' levels than the Tees-side group.

DIAGRAM 3

Graph I - Quality Control

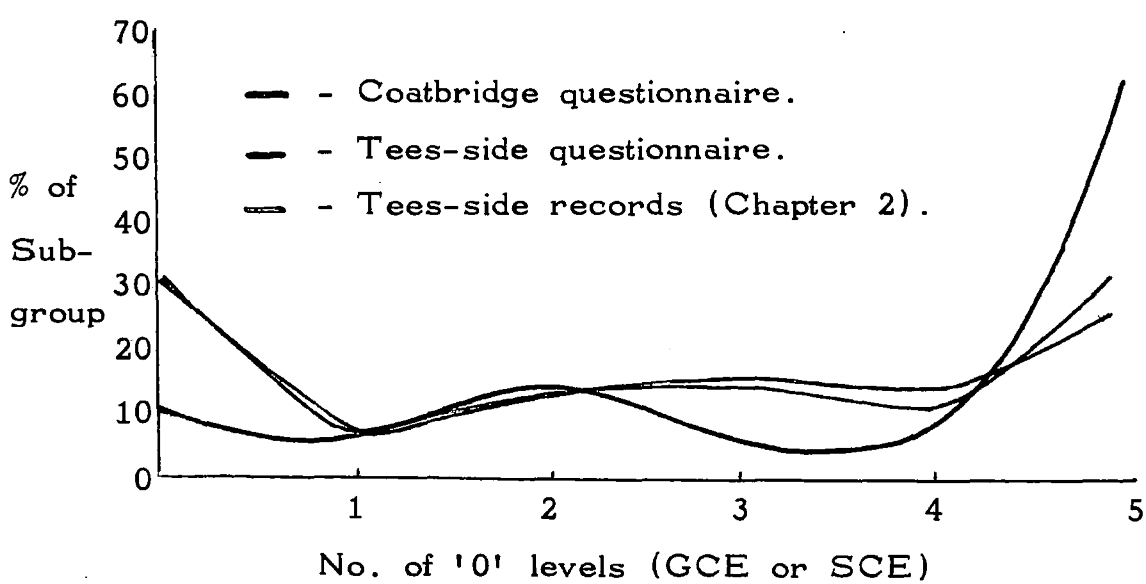
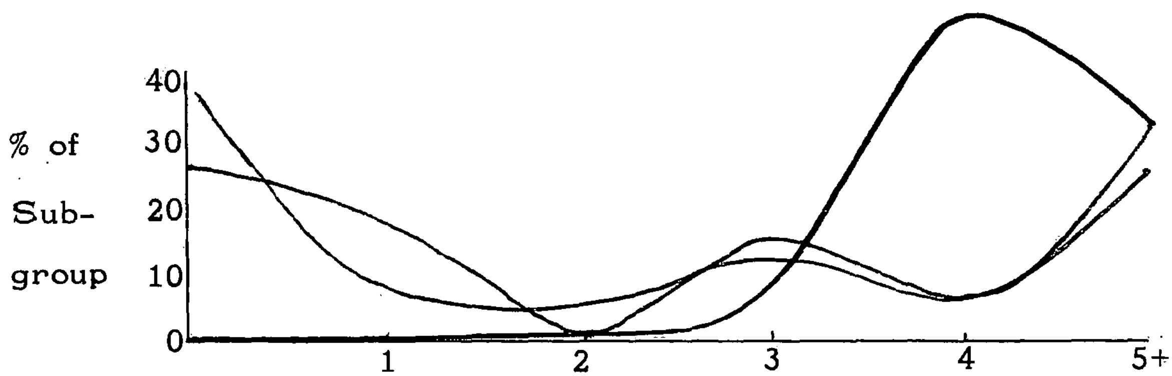
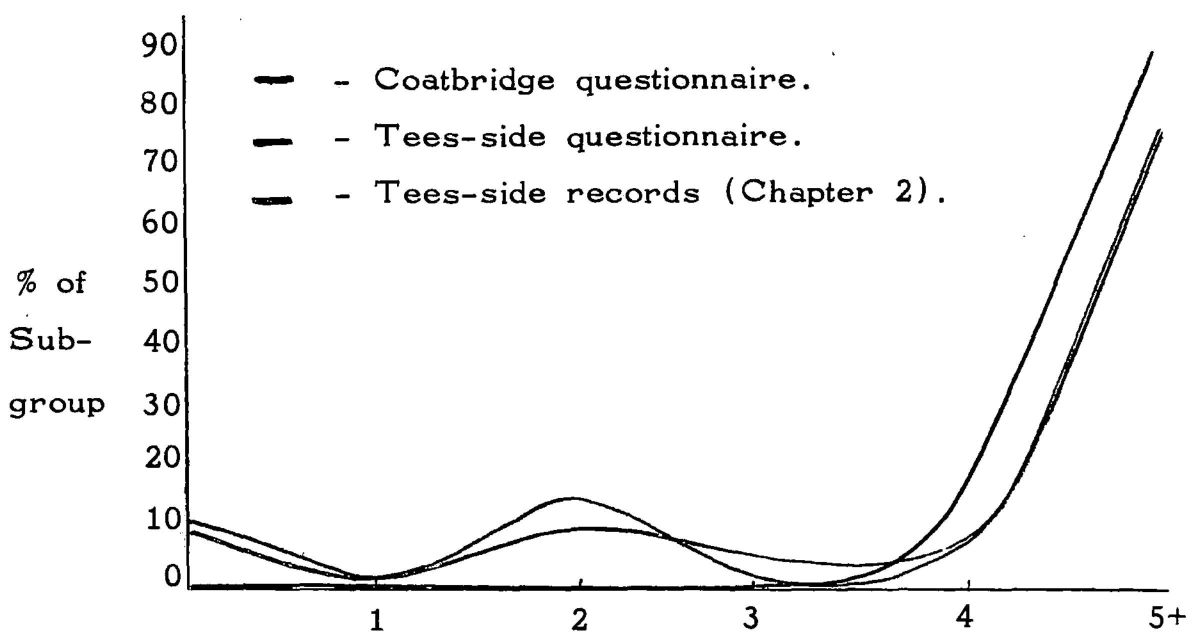


DIAGRAM 3 (Contd.)

Graph II - Engineering Application



Graph III - Research and Development



Investigating the way by which students selected a career in metallurgy and comparing the answers from Tees-side with those from Coatbridge a statistically significant difference at 1% (Fisher) was observed. Table XLVII expresses the answers to this set of questions as a percentage.

TABLE XLVII

Selection	Tees-side %	Coatbridge %
Made at school	45	69
Advised by YEO	10	4
Parent's request	7	5
Only job available	38	22

The main differences between the two groups of students were:-

1. The greater percentage of students from Coatbridge who entered upon a metallurgical career as the result of a decision taken at school. This may well be attributed to the fact that more students stayed on an extra year at school to gain Scottish Certificate Highers than students who stayed on for

two years to General Certificate Advanced grade in the English system.

2. The greater percentage of Tees-side students who entered metallurgy as the only job available. The more successful the pupil in school the more likely he would be able to choose between metallurgy, chemistry or engineering as a career. The difference between those students who were advised by the Youth Employment Officer and those who took the only job available was that in the former case students had approached the Youth Employment Officer with an open mind about their careers while the latter had entered the metallurgical industry as the only job available after trying independently to get jobs in other industries.

In discussion with the Youth Employment Officer it was revealed that many of the boys who had made their decision whilst at school had done so on the advice of the Youth Employment Officer or because they had a close relative in the industry. The Youth Employment Officer observed that those students who entered upon a metallurgical career as the only job available regarded the industry as a second-best and were not enthusiastic about their placings.

In talking to students it was evident that the great tradition of Iron and Steel making on Tees-side had an important bearing on the type of job the young person elected to follow. Discussions in school with the Careers' Master, the Youth Employment Officer and the Work's Education Officer, family involvement and ultimately good pay were reasons why students had decided upon this career.

On the question of the I.C.I. factory at Wilton versus the Iron and Steel industry one student explained that he was aware of the modern plant at Wilton, that he had visited certain sections of the factory including the apprentice training school but that he considered the unit to be impersonal and lacking in tradition. It was found that of the twenty five students, nineteen had some member of the family involved in the iron and steel work, and thirteen who had made their decision to enter the industry while at school felt that the enthusiasm of the Careers' Master had been instrumental in finalising their choice. Of the seven students who had entered metallurgical jobs as the only one available, four were happy in the job but not over enthusiastic about the future and three were decidedly unhappy and intended to leave the industry as quickly as possible. In this last category two were Modern schoolboys with no GCE '0' level passes and the third a Grammar schoolboy, had an '0' level pass in woodwork. These three students felt out of tune with their colleagues and expressed the view that study was extremely difficult for them.

In terms of the type of job one detected a sense of deep thinking among the students who had an opportunity of taking one or other of the three categories of jobs in this survey. Generally a greater sense of purpose and enthusiasm was expressed by students who were involved in research and development and engineering application than those in quality control. One Higher National Certificate student from Tees-side expressed the situation very fully when he said "Although my job is classified under research and development I find myself doing many routine chores but all of which have purpose to the development of a process and although it is the Chief Officer who takes the decisions I am always informed about the objectives and the planning stage and I always feel an important member of a team. I think that a technician involved in quality control is too far removed from the scene of activity even though he may go down to the shop floor to take his samples". This was substantiated by the comments of students in quality control jobs "What happens to our results?" and "What have we achieved?". The one case where a student had made quality control his choice was most impressive. He was a Grammar school student with 5 '0' levels (including chemistry, physics and mathematics), he knew he wanted to enter the metallurgical industry, examined the merits of research versus quality control and went on to say "I was conscious of the limited ceiling I would reach in research in spite of a good record in my technical school. I was convinced also that I was better than many who entered quality control type of jobs and therefore the promotion opportunity was better. I also realised that with a greater number of jobs in quality control the promotion opportunities were better anyway for those who were more able and who were prepared to work". This young man was determined to gain a post in Production Management. He was unusual in his approach. In presence, personality, awareness, thought and attitude to his studies he was superior to his colleagues and indeed to some of those who were working in research and development.

Shift Working

TABLE XLVIII

A. Students involved in shift working.

Involvement	Tees-side %	Coatbridge %
Yes	60	40
No	40	60

B. Shift working interfering with study - expressed as a percentage of those who answered "Yes" to section A.

Interference	Tees-side %	Coatbridge %
Yes	50	41
No	50	59

C. Provision to accommodate shift workers in the College - expressed as percentage of those who answered "Yes" to section A.

Provision	Tees-side %	Coatbridge %
Yes	56	0
No	44	100

An important educational factor in part-time courses is the opportunity to study regularly and continuously with the same team of teachers. It follows therefore that it is important to look at any issue that militates against good educational practice. Undoubtedly shift working can create difficulties not only by causing breaks in the continuity of study, but in the person-to-person contact between the students and the same teaching team. It is not enough to know whether students are involved in shift working but rather if shift working affects the periods of study and to what extent colleges are sympathetic to the problem. Table XLVIII summarises the results to question 6 as a percentage. Both Tees-side and Coatbridge students were involved in shift working and the statistical significant difference that existed between the two groups showed the Tees-side students in a less favourable light in terms of involvement.

Section B of Table XLVIII showed that 50% of the Tees-side students and 41% of the Coatbridge students who were involved in shift working considered that shift working interfered with their course of study. In terms of the total answers to the questionnaire this represents 30% of the Tees-side students and 16% of the Coatbridge students. Referring back to question 4 - Nature of Job - it was found that all the students who were affected by shift working were in quality control occupations. The 50% of the Tees-side students and the 59% of the Coatbridge students (section B - Table XLVIII) who considered that shift working did not interfere with study and who represented 30% and 24% of theTees-side and Coatbridge total sample respectively were given the appropriate day release irrespective of shift working.

Section C of Table XLVIII showed that 44% of the Tees-side students (equivalent to 26% of the total sample) were not provided with alternative classes as a means to solving the shift work problem. In the Coatbridge answers 100% were not given alternative classes and since this represents 40% of the total sample, it would suggest that in the final analysis, the Tees-side students are slightly better off than the Coatbridge students. The reason given by colleges for not offering alternative classes is that too few students are involved in any one stage of the course. In turn this adds strength to the suggestion that this course should be centralised in one college.

In discussing the question of shift working, students felt strongly about this issue in so far as they were being compared with those students who had the advantages of a regular way of life. One student put the position quite clearly when he said "Although the college does not provide alternative arrangements I doubt whether I would be any better served if I had one lecturer for two weeks and a different one for the third week. I find it most difficult to concentrate on my studies after working a shift, particularly if it has been a night shift. I consider it to be one stage worse than attending college on a wholly evening basis".

The general opinion of students in the Tees-side area was that if a comprehensive system of alternative classes was available in one centre it would be better to travel to that centre than have the discontinuity of study.

<u>The inclusion of metallurgy subjects at an early stage</u>.

TABLE IL

Inclusion	Tees-side %	Coatbridge %
Yes	96	95
No	4	4

Table IL expresses as a percentage the answers to question No. 7. There is no statistical significance between the two groups of students and both are overwhelmingly in favour of introducing metallurgical topics at an early stage. One student said that he felt very excited about leaving school and entering the big world of metallurgy but that his excitement was short lived when he realised that he had to return to a school class room and repeat some of the chemistry, mathematics and physics he had learned at school. Another student suggested that not only should metallurgical topics be introduced at an early stage but that some realism should be brought to the subsidiary subjects. He echoed the feeling of the majority of students interviewed when he said "I feel that the chemistry, mathematics and physics are taught in isolation and often by people who have no concern for the metallurgy student. The physics I have been taught have been introduced in such a purist way that I think the lecturer has forgotten I am studying an applied science". The general consensus of opinion was that the lack of metallurgical content at an early stage was responsible for frustration and failure. A student repeating S3 for the second time said "When I see my colleagues in mechanical engineering, building, chemistry and even commerce receiving instruction in their first year which has a direct bearing on their job I am concerned at the guidance I am receiving. One would think that if a Metallurgical Technician course could bring an early appraisal of metallurgical topics to the student then it should be possible to achieve a more enlightened structure for the National Certificate course in metallurgy".

Course content too academic and length of time to study

TABLE L

A. For all students

Too academic	Tees-side %	Coatbridge %
Yes	45	69
No	55	31

B. For S1, S2 and S3 students only

Too academic	Tees-side %	Coatbridge %
Yes	73	90
No	13	10

Note: The Coatbridge figures represent 01 (S3) year only.

The inclusion of metallurgical topics at an early stage in the course raised two further questions:-

1. Is the course content too academic?
2. Is there sufficient time to assimilate the course content?

Table L sets out the results to the first of these two questions under two headings:

A. For all students

B. For those students in the lower stages of the course (i.e. up to the level of the Ordinary National Certificate).

Referring to Appendix XXVIIIB question No. 8 the statistical calculations show that there was no statistically significant difference in the answer to the question between Tees-side and Coatbridge students up to the level of Ordinary National Certificate. An overwhelming majority of students were of the opinion that the course was too academic. However the calculations showed that there was statistical significant difference at 1% (Fisher) between all the Tees-side students and all the Coatbridge students. Opinions in both cases were less definite. Indeed the Tees-side results showed a reversal of opinion and a majority of all students did not consider the course to be too academic. This suggested that the more mature students could see some value in their early background studies.

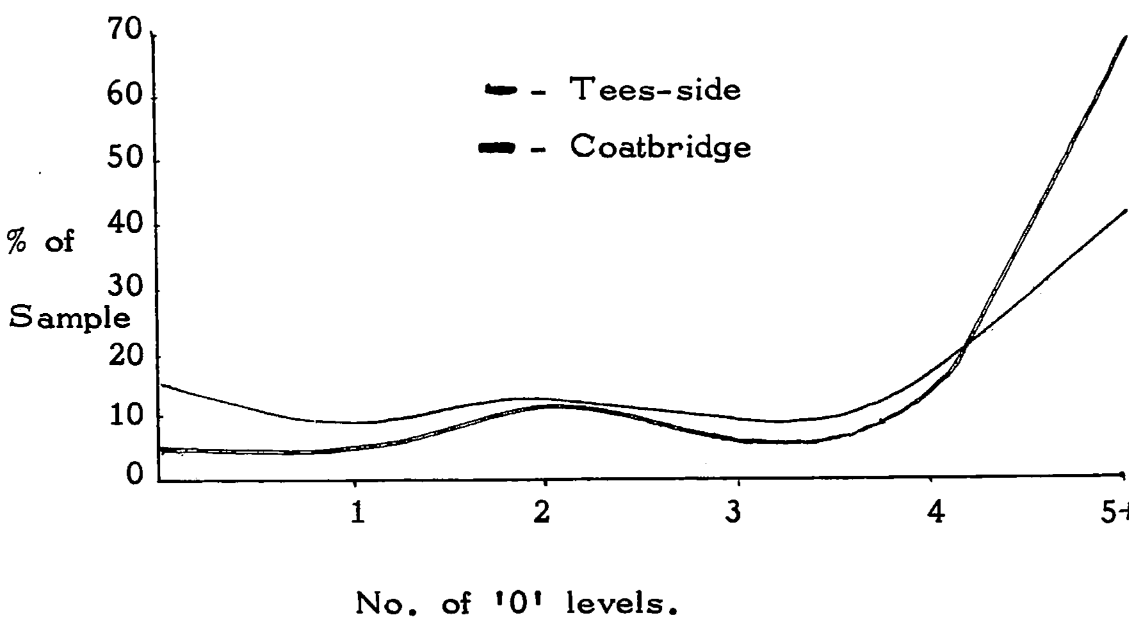
It was surprising to learn, however, (Table LI) that the students with 5+ 'O' levels represented the largest percentage of all students in both Tees-side and Coatbridge groups who regarded the course to be too academic.

<u>TABLE LI</u>

<u>Number of '0' levels gained by students who thought the course content was too academic</u>

	Tees-side						Coatbridge					
No. of '0' levels	0	1	2	3	4	5+	0	1	2	3	4	5+
% of sample	15	9	11	9	15	40	3	3	11	6	11	66

<u>DIAGRAM 4</u>



It was significant too, that the majority of students who believed that metallurgical topics should be introduced at an early stage also suggested that this would act as an antedote to the too academic approach. One student from Constantine College studying at the S3 stage expressed the view that 'General Metallurgy' at this level was very much a 'give-away' subject embracing too many topics in a superficial manner and not appearing to be integrated with the rest of the course. He quoted, for example, the case of Young's Modulus being taught as an isolated issue in physics and tensile strength as another topic in General Metallurgy, and again the teaching of the elements of fuel technology in General Metallurgy without reference to the combustion taught in chemistry. The student was of the opinion that the content of the General Metallurgy syllabus could well be distributed throughout the chemistry and physics syllabus. The general opinion of all students interviewed was that the teaching of physics and chemistry ought to be controlled by teachers of metallurgy in order to apply the fundamentals of physics and chemistry to metallurgy.

One of the problems associated with part-time study and one of the issues that receives periodic comment from teaching staff is the time allocated to the quantity of syllabus content. It is remarkable that teachers themselves draw up the syllabuses and complain that they haven't time to teach all they have recommended in the syllabus. Time and time again they lose out on prescribing details instead of fundamentals. In effect the development of technology is creating a situation in which the student is being asked to learn more and more without due consideration for the amount of time needed to learn both in breadth and depth. It was this situation that led to question No. 9 of the questionnaire (Appendix 27) and Table LII sets out the results to this question as a percentage.

TABLE LII

Sufficient time to assimilate course content	Tees-side %	Coatbridge %
Yes	34	44
No	66	56

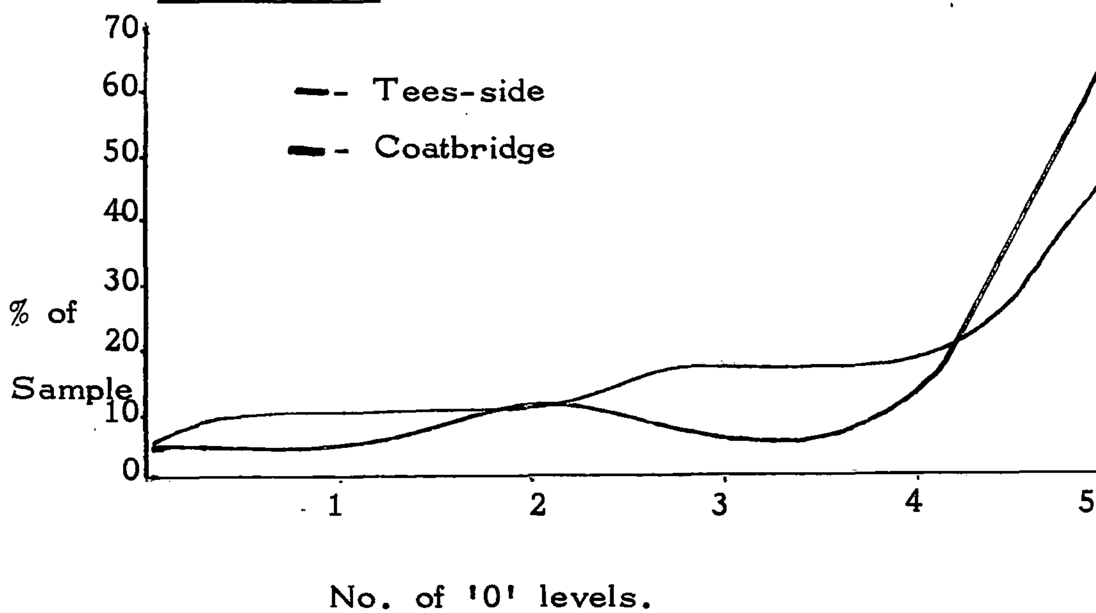
There is no statistical difference between the two areas. It is clear that the majority of students consider that there was sufficient time to gain a full understanding of the syllabus content as presented to them. Again a comparison was made of the number of '0' levels gained by students and their time to assimilate syllabus content. Students with the better entry qualifications represented the greatest percentage of the total population who wished to have a longer time to understand the syllabus. Table LIII and graph (diagram 5) shows the distribution of these results.

TABLE LIII

Number of '0' levels gained by students who did not think they had sufficient time to assimilate course content.

	Tees-side						Coatbridge					
No. of '0' levels	0	1	2	3	4	5+	0	1	2	3	4	5+
% of sample	5	10	10	16	16	43	2	2	2	9	13	72

DIAGRAM 5



Interesting observations were made by interviewees on the adequacy of time to study. The main opinions were centred round the difference between working and studying at college and learning at school. One sixteen years old student entering the S2 year with six '0' level passes had found study at school to be well within his grasp. The complexity of work and study came as something of a shock and while he was anxious to do well at both work and college his first priority was the firm and not the college. It is not uncommon to find the young person to be an excellent employee but a poor student. Students felt that work and study were a way of life to which they had to have time to acclimatise and which could account for failure in their first year in college. The tempo of life at work and college was so much faster than at school and the demands made upon them more exacting.

Applicability to the job of the subjects studied.

The relevancy of course content to the job is an issue that all students are ready to appraise. It was therefore considered to be worthwhile to investigate student reaction to topics in mathematics, chemistry and physics. Students were asked to express their answers in terms of a five point scale from 1 (essential) through 2, 3, 4 to 5 (unessential) and the answers to these questions are shown in Appendix XXIX. Table LIV shows the results to the questions in terms of histograms.

Two different samples were taken:-

1. The total population and
2. The population covered by the S3, A1 and A2 years.

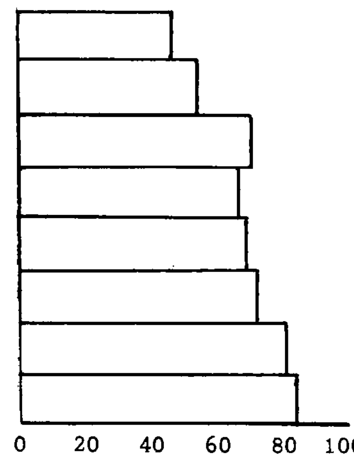
TABLE LIV

MATHEMATICS

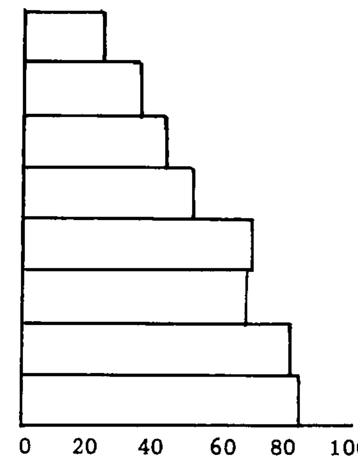
Answers Expressed as %
of Topics Studied
for all Students

TOPIC	Tees-side 1+2	Tees-side 3	Tees-side 4+5	Coatbridge 1+2	Coatbridge 3	Coatbridge 4+5
Mensuration	44	10	46	62	14	24
Algebra	31	15	54	42	23	35
Geometry	15	14	71	31	18	51
Trigonometry	21	12	67	32	25	43
Differential Calculus	19	12	69	18	12	70
Integral Calculus	20	7	73	21	11	68
Partial Differentiation	11	8	81	9	9	82
Co-ordinate Geometry	11	5	84	6	9	85

Histograms of Col. 4+5



Tees-side



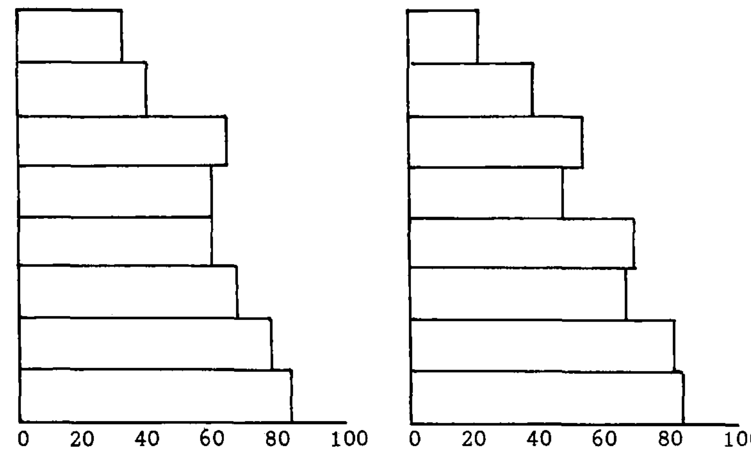
Coatbridge

MATHEMATICS

Answers Expressed as %
of Topics Studied by those
at S3, A1 & A2 level only

TOPIC	Tees-side 1+2	Tees-side 3	Tees-side 4+5	Coatbridge 1+2	Coatbridge 3	Coatbridge 4+5
Mensuration	53	15	32	64	15	21
Algebra	43	18	39	42	20	38
Geometry	20	16	64	31	16	53
Trigonometry	30	10	60	32	22	46
Differential Calculus	26	14	60	20	12	68
Integral Calculus	26	7	67	22	12	66
Partial Differentiation	14	9	77	10	8	82
Co-ordinate Geometry	12	4	84	6	11	83

Histograms of Col. 4+5



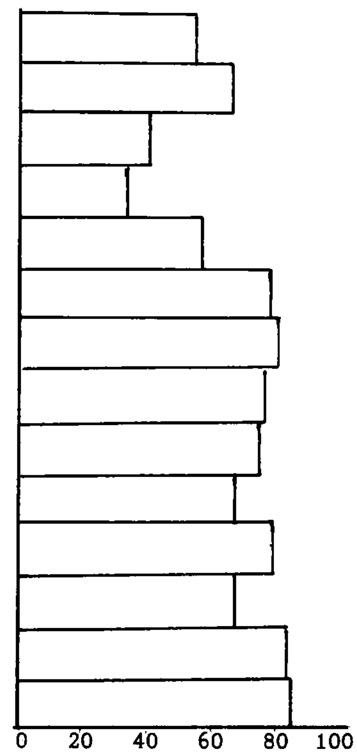
Tees-side Coatbridge

INORGANIC CHEMISTRY

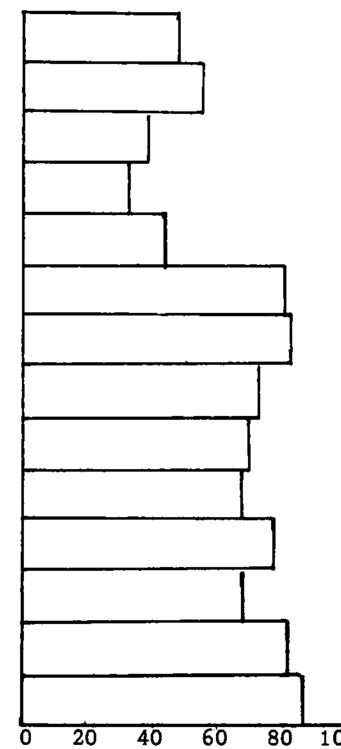
Answers Expressed as %
of Topics Studied
for all Students

TOPIC	Tees-side 1+2	Tees-side 3	Tees-side 4+5	Coatbridge 1+2	Coatbridge 3	Coatbridge 4+5
Study of Water	30	15	55	32	21	47
" " Halogens	18	16	66	24	21	55
Phosphorus & Comps.	33	28	39	45	17	38
Sulphur & Compounds	35	32	33	48	18	33
Nitrogen & Compounds	18	26	56	46	11	43
Manufacture of Na_2CO_3	12	11	77	12	6	82
$NaHCO_3$	8	12	80	12	6	82
NH_3	9	15	76	11	15	74
HNO_3	9	17	74	18	12	70
HCl	14	20	66	20	12	68
H_2SO_4	12	21	77	19	14	77
Graphite	22	12	66	24	11	67
Glass	12	6	82	10	8	82
CS_2	7	10	83	8	5	87

Histograms of Col. 4+5



Tees-side



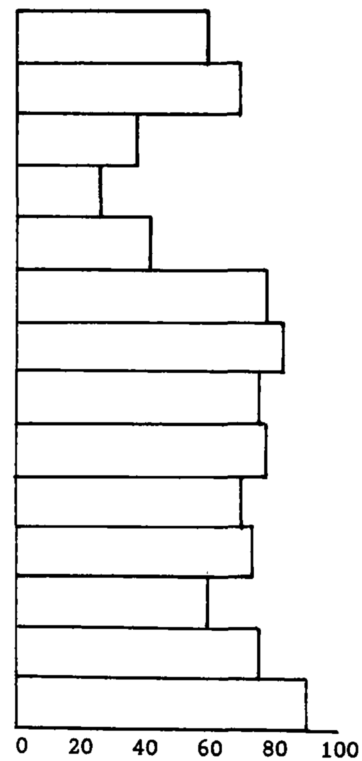
Coatbridge

INORGANIC CHEMISTRY

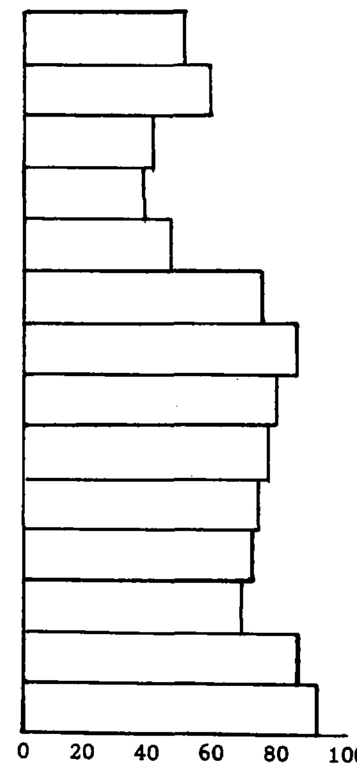
Answers Expressed as % of Topics Studied by those at S3, A1 & A2 level only

TOPIC	Tees-side 1+2	Tees-side 3	Tees-side 4+5	Coatbridge 1+2	Coatbridge 3	Coatbridge 4+5
Study of Water	32	9	59	33	17	50
" " Halogens	11	20	69	25	18	57
Phosphorus & Comps.	19	43	37	46	14	40
Sulphur & Compounds	28	46	26	47	16	37
Nitrogen & Compounds	20	39	41	46	9	45
Manufacture of Na_2CO_3	9	14	77	10	16	74
$NaHCO_3$	7	11	82	11	4	85
NH_3	11	14	75	9	13	78
HNO_3	11	11	77	14	10	76
HCl	11	16	70	17	10	73
H_2SO_4	11	18	73	17	12	71
Graphite	26	16	58	21	12	67
Glass	15	10	75	6	9	85
CS_2	5	5	90	4	5	91

Histograms of Col. 4+5



Tees-side



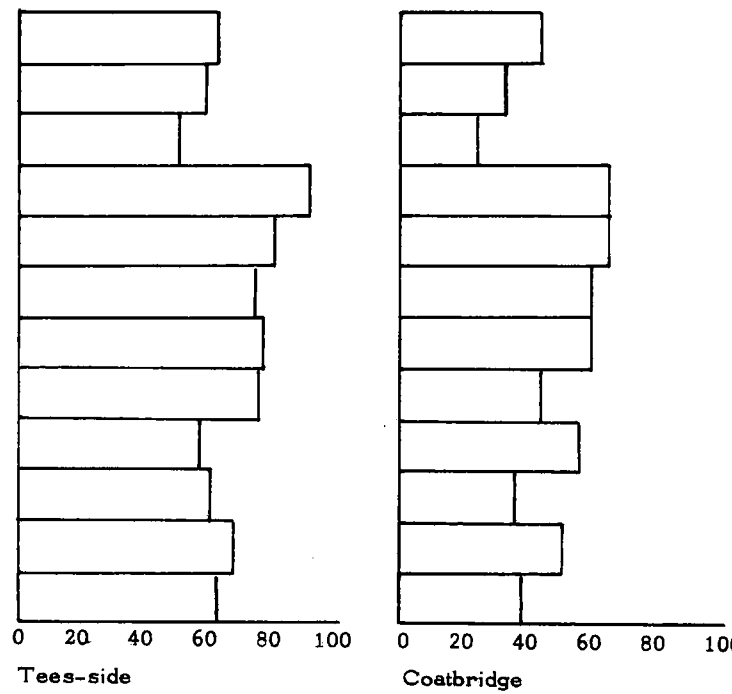
Coatbridge

PHYSICAL-CHEMISTRY

Answers Expressed as %
of Topics Studied
for all Students

TOPIC	Tees-side 1+2	Tees-side 3	Tees-side 4+5	Coatbridge 1+2	Coatbridge 3	Coatbridge 4+5
Chemical Equilibrium	24	12	64	41	15	45
Electro Chemistry	26	13	61	47	18	33
Thermo Chemistry	31	17	52	60	16	24
Osmosis	4	3	93	23	11	66
Det. of Vapour Densities	9	10	81	23	13	66
Elevation of B.P.	13	11	76	22	17	61
Depression of F.P.	12	10	78	26	13	61
Heat of Neutralisation	12	11	77	35	20	45
Det. of Elect. Cond.	21	21	58	24	20	56
Det. of Molecular Wt.	24	14	62	50	14	36
Det. of Transition Pts.	22	9	69	37	12	51
Potentiometric Tit.	28	8	64	46	17	37

Histograms of Col. 4+5

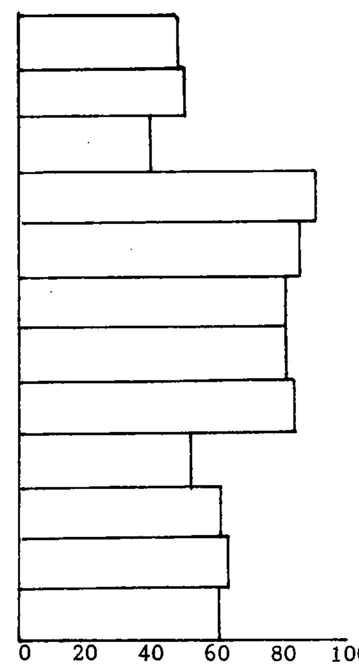


PHYSICAL-CHEMISTRY

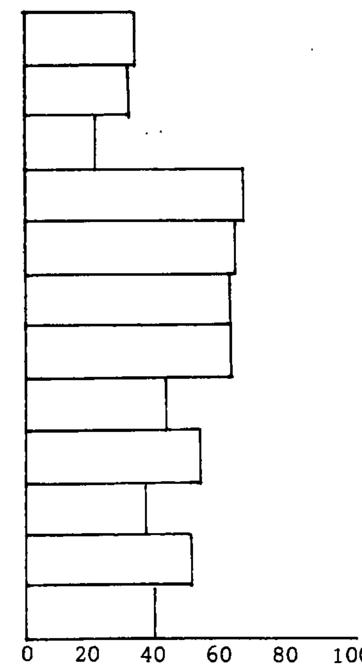
Answers Expressed as %
of Topics Studied by those
at S3, A1 & A2 level only

TOPIC	Tees-side 1+2	Tees-side 3	Tees-side 4+5	Coatbridge 1+2	Coatbridge 3	Coatbridge 4+5
Chemical Equilibrium	40	11	49	51	16	33
Electro Chemistry	35	15	50	48	20	32
Thermo Chemistry	42	18	40	62	17	21
Osmosis	7	3	90	24	10	66
Det. of Vapour Densities	11	5	84	23	14	63
Elevation of B.P.	11	9	80	21	17	62
Depression of F.P.	11	9	80	24	14	62
Heat of Neutralisation	14	5	81	36	21	43
Det. of Elect. Cond.	24	24	52	25	22	53
Det. of Molecular Wt.	23	15	62	52	13	36
Det. of Transition Pts.	26	10	64	39	11	50
Potentiometric Tit.	26	13	61	46	15	39

Histograms of Col. 4+5



Tees-side



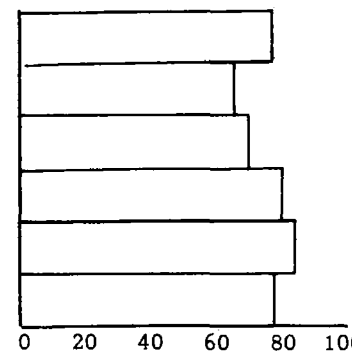
Coatbridge

PHYSICS-HEAT

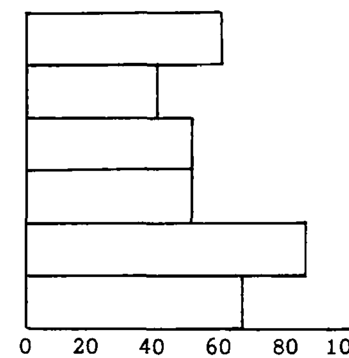
Answers Expressed as %
of Topics Studied
for all Students

TOPIC	Tees-side 1+2	Tees-side 3	Tees-side 4+5	Coatbridge 1+2	Coatbridge 3	Coatbridge 4+5
Charles' Law	12	11	77	33	15	52
Spec. & Latent Heat	15	19	66	44	17	39
Mech. Equiv. of Heat	14	16	70	37	14	50
Vapour Pressure	11	10	79	26	24	50
Dew Pt. & Humidity	11	5	84	12	4	84
Liquefaction	10	12	78	20	15	65

Histograms of Col. 4+5



Tees-side



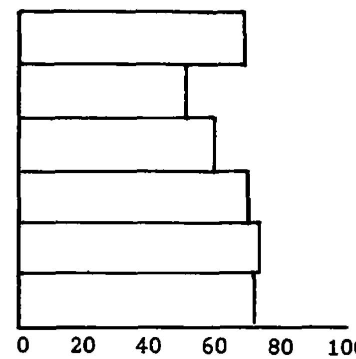
Coatbridge

PHYSICS-HEAT

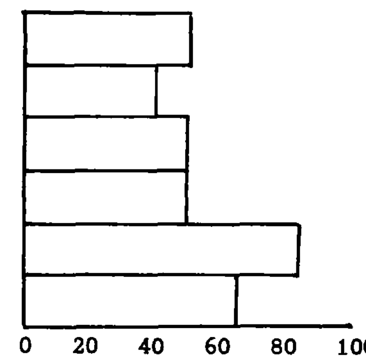
Answers Expressed as %
of Topics Studied by those
at S3, A1 & A2 level only

TOPIC	Tees-side 1+2	Tees-side 3	Tees-side 4+5	Coatbridge 1+2	Coatbridge 3	Coatbridge 4+5
Charles' Law	12	19	69	34	14	52
Spec. & Latent Heat	22	26	52	45	15	40
Mech. Equiv. of Heat	17	22	61	37	14	49
Vapour Pressure	18	15	70	27	24	49
Dew Pt. & Humidity	19	7	74	12	3	85
Liquefaction	14	14	72	21	13	66

Histograms of Col. 4+5



Tees-side



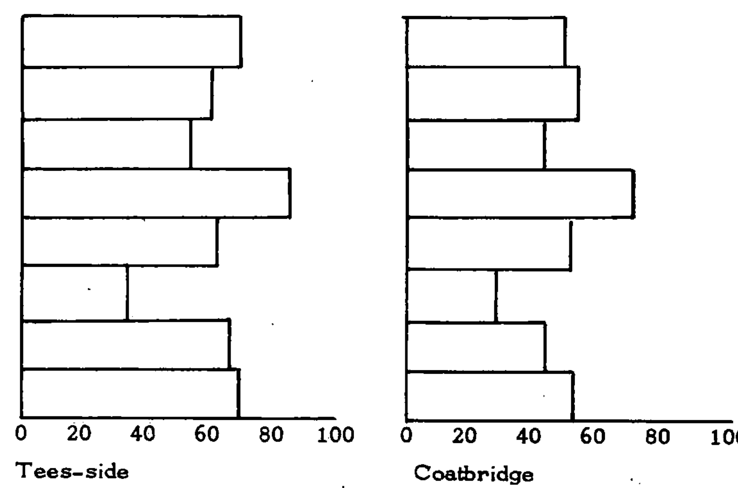
Coatbridge

PHYSICS - ELECTRICITY AND MAGNETISM

Answers Expressed as %
of Topics Studied
for all Students

TOPIC	Tees-side 1+2	Tees-side 3	Tees-side 4+5	Coatbridge 1+2	Coatbridge 3	Coatbridge 4+5
Magnetic effect	21	11	68	34	18	48
Elect. power & energy	26	15	59	33	14	53
Electrolysis	17	20	53	42	16	42
Static Electricity	12	5	83	19	11	70
Current Electricity	23	16	61	34	15	51
Electrical measurement	49	18	33	65	7	28
Photoelectric and thermionic effect	24	11	65	41	15	44
Cathode ray oscilloscope	18	14	68	35	13	52

Histograms of Col. 4+5

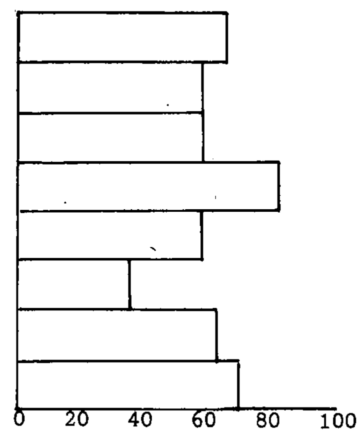


PHYSICS - ELECTRICITY AND MAGNETISM

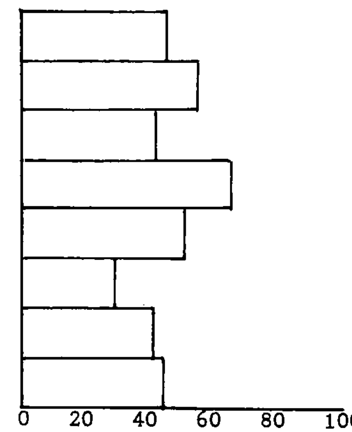
Answers Expressed as % of Topics Studied by those at S3, A1 & A2 level only

TOPIC	Tees-side 1+2	Tees-side 3	Tees-side 4+5	Coatbridge 1+2	Coatbridge 3	Coatbridge 4+5
Magnetic effect	23	11	66	35	19	46
Elect. power & energy	26	16	58	32	13	55
Electrolysis	23	19	58	41	17	42
Static Electricity	11	6	83	17	12	71
Current Electricity	23	19	58	33	16	51
Electrical measurement	50	15	35	62	9	29
Photoelectric and thermionic effect	29	9	62	43	16	41
Cathode ray oscilloscope	14	16	70	38	18	44

Histograms of Col. 4+5



Tees-side



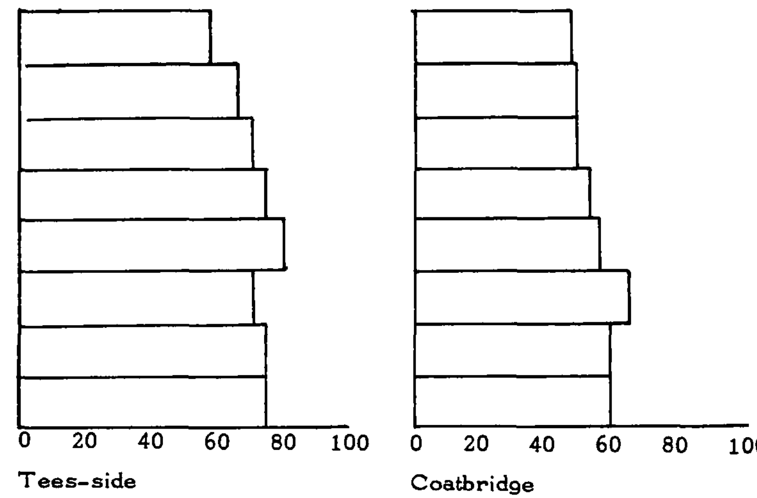
Coatbridge

PHYSICS-MECHANICS

Answers Expressed as %
of Topics Studied
for all Students

TOPIC	1+2	3	4+5	1+2	3	4+5
Work, Energy, Power	19	24	57	37	16	47
Levers, Simple machines	19	15	66	36	16	48
Force	18	11	71	32	20	48
Pressure in fluids	19	6	75	33	15	52
Boyle's Law	10	10	80	31	14	55
Archimedes Principle	17	12	71	26	9	65
Surface Tension	14	11	75	27	14	59
Dynamics	14	10	75	27	14	59
	Tees-side			Coatbridge		

Histograms of Col. 4+5



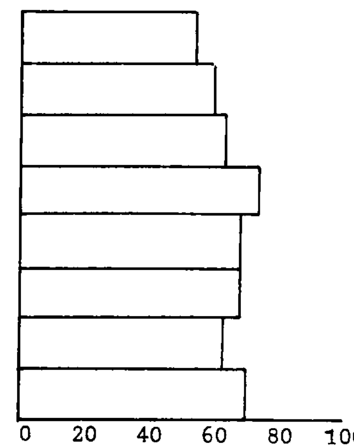
PHYSICS-MECHANICS

Answers Expressed as %
of Topics Studied by those
at S3, A1 & A2 level only

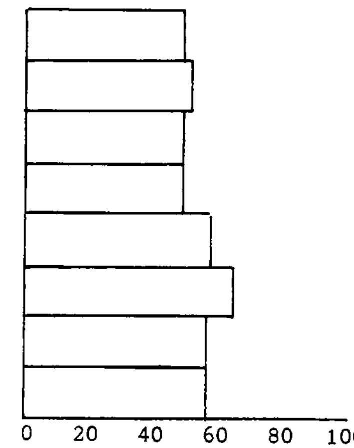
Histograms of Col. 4+5

TOPIC	Tees-side 1+2	Tees-side 3	Tees-side 4+5	Coatbridge 1+2	Coatbridge 3	Coatbridge 4+5
Work, Energy, Power	23	23	54	37	14	49
Levers, Simple machines	23	17	60	35	14	51
Force	19	17	64	32	19	49
Pressure in fluids	17	9	74	35	16	49
Boyle's Law	15	17	68	32	11	57
Archimedes Principle	15	17	68	27	8	65
Surface Tension	22	15	63	30	14	56
Dynamics	20	10	70	29	15	56

Tees-side Coatbridge



Tees-side



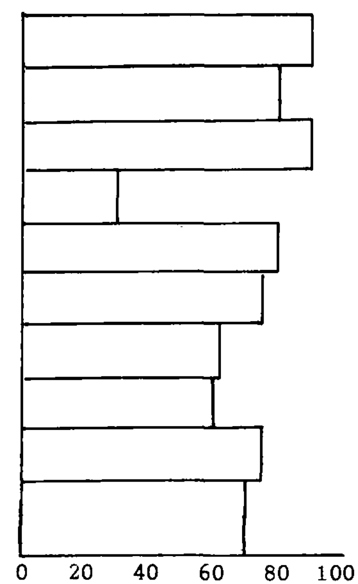
Coatbridge

PHYSICS-LIGHT

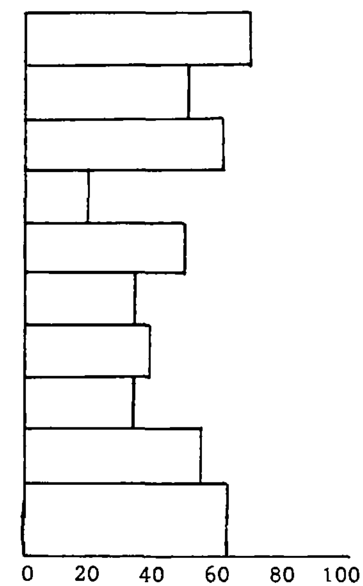
Answers Expressed as %
of Topics Studied
for all Students

TOPIC	1+2	3	4+5	1+2	3	4+5
Reflection	5	6	89	28	13	69
Refraction	6	15	79	32	17	51
Telescope	4	7	89	24	15	61
Microscope	51	20	29	66	13	19
Wave Theory	12	7	79	26	25	49
Spectrum (Electro Mag.)	16	10	74	48	17	34
X-rays	28	14	61	49	13	38
Spectrometer	24	16	60	40	16	34
Polarimeter	13	13	74	25	21	54
Phosphorescence and fluorescence	10	11	69	23	14	63
	Tees-side			Coatbridge		

Histograms of Col. 4+5



Tees-side



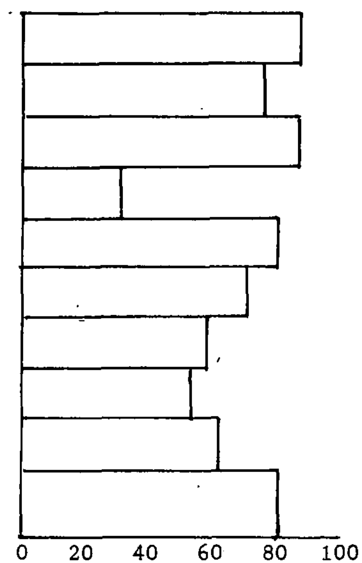
Coatbridge

PHYSICS -LIGHT

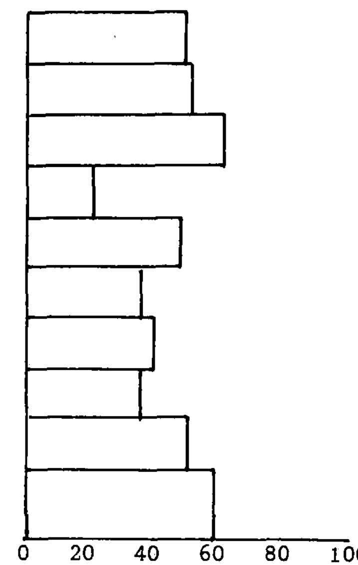
Answers Expressed as % of Topics Studied by those at S3, A1 & A2 level only

TOPIC	Tees-side 1+2	Tees-side 3	Tees-side 4+5	Coatbridge 1+2	Coatbridge 3	Coatbridge 4+5
Reflection	6	8	86	40	11	49
Refraction	8	17	75	35	15	50
Telescope	4	10	86	26	14	60
Microscope	52	17	31	67	12	21
Wave Theory	16	5	79	27	25	48
Spectrum (Electro Mag.)	20	10	70	47	17	36
X-rays	23	19	58	48	12	40
Spectrometer	24	24	52	48	16	36
Polarimeter	17	22	61	27	23	50
Phosphorescence and fluorescence	7	14	79	22	20	58

Histograms of Col. 4+5



Tees-side



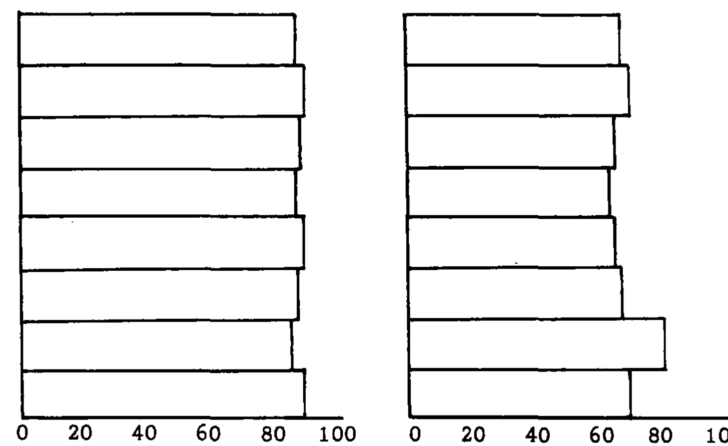
Coatbridge

PHYSICS-SOUND

Answers Expressed as %
of Topics Studied
for all Students

TOPIC	1+2	3	4+5	1+2	3	4+5
Wave Motion	8	6	86	25	7	68
Amplitude	7	5	88	25	5	70
Wave Length	8	5	87	28	9	65
Velocity	8	6	86	25	11	64
Reflection	7	5	88	25	9	66
Frequency	8	5	87	29	4	67
Sonometers	7	8	85	12	7	81
Resonance	5	6	89	21	9	70
	Tees-side			Coatbridge		

Histograms of Col. 4+5



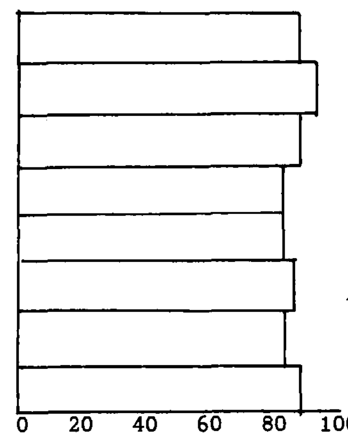
Tees-side Coatbridge

PHYSICS - SOUND

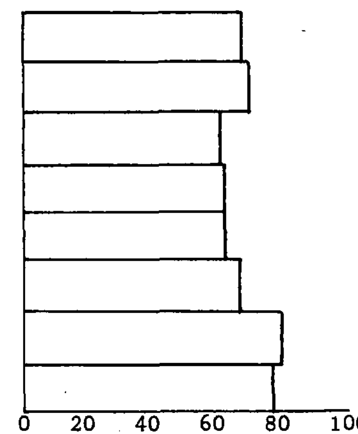
Answers Expressed as %
of Topics Studied by those
at S3, A1 & A2 level only

Histograms of Col. 4+5

TOPIC	1+2	3	4+5	1+2	3	4+5
Wave Motion	8	4	88	28	5	67
Amplitude	7	0	93	28	3	69
Wave Length	8	4	88	31	8	61
Velocity	11	6	83	28	10	62
Reflection	13	4	83	28	8	62
Frequency	8	6	86	31	3	66
Sonometers	9	7	84	14	6	80
Resonance	7	5	88	18	5	77
	Tees-side			Coatbridge		



Tees-side



Coatbridge

– In the first case there was a marked similarity to the pattern of histograms between the Tees-side and Coatbridge answers but with a stronger feeling among the Tees-side students that a greater majority of the topics had little or no value in their work-a-day world. This first analysis showed such marked similarities that it was considered essential to re-examine the questions at more mature level, it being considered that the answers of the younger students might well be influenced by many of the comments they had made to the general section of the questionnaire. An examination of answers from students at S3, A1 and A2 years showed the same patterns and indeed in some areas the similarity became even closer.

From the histograms in mathematics it can be seen that higher mathematics - calculus and co-ordinate geometry is regarded as being of little value or even unessential. This is not surprising in light of the number of students involved in quality control occupations. The ceiling in mathematics was well beyond the limit needed for this purpose and supports the theory that National Certificates should not be the course for quality control technicians. In discussion, students expressed the view that up to half the time spent on mathematical topics was considered to be irrelevant to the job. Of the forty students interviewed, nineteen (almost half the sample) would have welcomed some instruction in statistics in order to help with sampling techniques.

In the field of chemistry students were more tolerant of syllabus content although they were critical of the inclusion of so many manufacturing processes. Not a single student interviewed could appreciate the reason for including carbon disulphide in the manufacturing processes. Although two students knew that carbon disulphide is used as a solvent they did not know any use for the substance in any metallurgical process. Twenty eight teachers of chemistry who were questioned had not seen carbon disulphide manufactured and yet many were teaching the process to students. In discussing the place of chemistry in metallurgical courses one student said "At present we are given details of manufacturing processes for all sorts of chemicals by a grammar shcool teacher, teaching part-time evening classes with no experience of industry and using "Intermediate Chemistry" by Lowry and Cavell as his source book. It is quite obvious that he hasn't seen the majority of those processes and we could quite well read the book ourselves". In spite of their reluctance to adapt their thoughts to higher mathematics students were interested in physical chemistry. They were concerned to use physical-chemical concepts to solve problems quickly. Thus electrochemistry, conductivity and potentiometric titration concepts were popular with the metallurgical analysist while electro-chemistry was important to the physical metallurgist. In discussion with students it was observed that knowledge of physical chemistry was superficial and of a qualitative nature.

Physics received the greatest criticism from the students. The general comments showed a complete lack of application of physics to metallurgy. Between 66% and 84% of the students could not see value in the teaching of heat. This is most disconcerting when it is considered that by far the largest proportion of extraction processes involve thermal energy and in the interest of good economy the fundamentals of heat exchange must be studied. The need to understand electricity seemed to be more appreciated by students particularly in the field of instrumentation where students were taught the control of plant by instrument control. Nevertheless it is a sad reflection to note that 83% of the students could see no value in static electricity. The cleaning of gases and the reclaiming of solid particles from fume are examples of static electricity application that might have been taught to students. No evidence of students receiving such instruction was forthcoming. Again the non-destructive testing technician was interested in electricity as a means of detecting and measuring flaws and cracks. Again the study of mechanics was regarded as a waste of time in spite of the fact that all topics listed had bearing on some metallurgical process, thus the use of surface tension in a froth flotation cell and the mechanics of distribution of the blast furnace burden. The teaching of such applications could make the subject a real issue. All the topics listed under the heading of light have direct application to the metallurgical industry. It is difficult to appreciate that only 29% of the Tees-side students find the microscope unnecessary and yet 89% regard the study of reflection and 79% regard the study of refraction unnecessary. This suggests that there is no co-ordination between the teaching of one aspect of light with another let alone the teaching of the application to metallurgical problems. The use of the spectrometer and polarimeter in analytical studies, the use of X-rays and fluorescence in non-destructive testing, the use of the microscope to the physical metallurgist - all these topics should be taught with the emphasis on the metallurgical application but again no evidence of this was evident in discussion with the students. Discussing the teaching of the sound, students did not regard this subject with seriousness. Between 86 - 89% of all the Tees-side students could see no relevance for the teaching of all the topics in sound and in discussion no student could offer examples of the use of sound for metallurgical purposes.

The outcome of the criticism of subject content poses many questions associated with the philosophy of the course. "Is it educationally sound for students to be taught by chemists, physicists and mathematicians who have not been in the metallurgical industry? Is it educationally sound for the type of student on National Certificate courses to be taught by chemists, physicists and mathematicians who have received no formal training in the principles of teaching (out of twenty nine teachers involved in metallurgy courses seven had taken a course in teacher training)? Should the course treatment at the early stages follow the same lines as the National Certificate in chemistry? Should not the metallurgy student be made to feel that his course ranks as high as the next, whether it be chemistry or engineering?".

From these observations there is need to re-appraise the subject content of the course and this must be done in such a way that the student has time to study. Much of the content of metallurgical courses in the past has been influenced by the fact that many of the pioneers of the early industry were firstly chemists and since that time the accent has changed radically to a physical bias without the course content keeping pace with this change.

Summary of Chapters II and III

Chapter II

(a) Standardisation of nomenclature to ONC S1, S2, S3 and HNC H1, H2 and the location of colleges in Tees-side area.

(b) Inspection of records.

(c) 5% of student population gained ONC with failure at any stage.

(d) 8% of student population entering at S2 gained ONC without failure at any stage.

(e) Grammar school system of education not a criterion by which success in a National Certificate in metallurgy could be judged. 79% of students came from grammar schools.

(f) GCE not a good selection for the course when considered in the context of the job and part-time education.

(g) Majority of students in quality control jobs - need for a different type of course, i.e. Technicians course.

(h) Imposition of passing each year of National Certificate course.

(i) Need for closer integration between similar types of industry and college.

<u>Chapter III</u>

(a) Concerned with observations of students by (i) Questionnaire, (ii) Interview.

(b) Comparisons with other National Certificates.

(c) Course too academic.

(d) Lack of time for assimulation of course content.

(e) Need for greater flexibility in course.

Chapter IV

Conclusions and Recommendations

The aim of the previous chapters has been to appraise metallurgical education on Tees-side by:-

1. An examination of the historical background that led to the introduction of the National Certificate in metallurgy.
2. An inspection of the records of students at Tees-side colleges and a comparison of these with results from other centres.
3. An inquiry by questionnaire and interview of students in order to appraise their reaction to the course.

1. Historical Background

Almost a complete cycle of events can be traced through the deliberations of the City and Guilds committee for metallurgy.

At the outset the object was to provide course content and examination suitable for a technician qualification. By 1930 the committee had agreed to include chemistry and physics as fundamental sciences necessary to the study of metallurgy. Many of the pioneers of the metallurgical industry had received a chemical training and this may well have influenced the inclusion of chemistry and physics in the course. The scheme - Principles and Practices of Metallurgical Operations - provided the basis for the first National Certificate which was introduced in 1945. The National Certificate in metallurgy had been delayed on two counts:-

1. The small number of students studying for metallurgy throughout the Country.
2. The absence of a professional institution from which representation could be sought to form a Joint Committee to administer the Certificate scheme.

The reason for the introduction of a National Certificate in metallurgy was to give equal opportunity to all students, from all over the Country, who were capable of benefitting by such a course of study.

Previously, opportunity had been limited and localised to such qualifications as the part-time Sheffield University Associateship course, the Associateship of the Manchester College of Technology and the Associateship of the Royal College of Technology, Glasgow.

Recognising the fact that the National Certificate was intended to meet the needs of local industry, more and more colleges, as they became familiar with the modus operandi of the National Certificate elected to devise and operate their own course of study. Concurrently regional examining councils were offering Ordinary National Certificate schemes. The net result of this diversification was a sharp fall in the number of students preparing for the City and Guilds examinations particularly in chemistry and physics. In spite of the fact that the City and Guilds course was renamed "Metallurgy" in 1953, the scheme was gradually phased out, the intermediate examination in 1963 and the final examination in 1965. A major complaint in the use of the City and Guilds course for National Certificate purposes was the time taken to mark scripts firstly for the City and Guilds qualification and secondly the moderating by the Joint Committee's assessors. It was found that the results of the latter was not reaching colleges until well into the next session and this was causing embarrassments in the misplacing of students.

With the eclipse of the course "Metallurgy" in 1965, the City and Guilds adopted the Metallurgical Technicians Certificate and the Metallurgical Technicians Advanced Certificate and it was significant that the scheme re-introduced metallurgy in the first year of the course. This was an incentive that had been missing from the first two years of the National Certificate course and was a factor that had received severe criticism from those students who were struggling to gain an Ordinary National Certificate.

The other important pronouncement that closed this chapter of events came from the Institution of Metallurgists.

In 1966 they ceased to recognise the Higher National Certificate for exemption purposes.

These issues, coupled with the fact that there has been a widening of the gap between the educational needs of the technologist and the technician, leads one to conclude that there will be a decreasing number of students preparing for National Certificates and an increasing number of students preparing for the technician courses.

If it is considered that the Higher National Certificate is one of the courses that should be available for metallurgical studies, then its ordering should be as follows:

1.	Degree or equivalent	Technologist
2.	Higher National Diploma	Technologist
3.	Higher National Certificate	Higher Technician
4.	Advanced Technician Certificate	Lower Technician

It is doubtful whether a three year Sandwich Diploma course would survive against a four year Council for National Academic Awards degree sandwich course. It is conceivable too, that the Advanced Technician Certificate could so develop in course content as to lose its value as a lower technician qualification and make the Higher National Certificate unnecessary. If the evolution of the technician course followed this pattern it may become subjected to the same criticism of high failure rates, that has been levelled at the National Certificate course. In effect there would be a danger of the cycle repeating itself.

2. Inspection of Records

When it is considered that only 5% of the total student population inspected gained an Ordinary National Certificate without failure at any stage, and even worse, when it is considered that 8% of those entering at the S2 year (implying an entry qualification of General Certificate of Education '0' level passes in chemistry, physics and mathematics, or equivalent) gained an Ordinary National Certificate without failure at any stage and when it is known that 79% of the students entered the National Certificate course from grammar schools, the first impulse would be to suggest that the grammar school system of education was not a criterion by which success in the National Certificate in metallurgy could be judged. While the records showed that the chances of passing were greater among those students who had 'O' level passes in chemistry, physics and mathematics, the high failure rates suggest that a grammar school education or success in G.C.E. is not a good selector for the Ordinary National Certificate course. It would be unjust and unwise to consider this comment in isolation since the type of job and the system of part-time further education play their part in success and failure.

The records showed that the majority of students, 219 out of a total of 285, were in jobs of a quality control nature and of these 174 students came from grammar schools. At the time of the survey the National Certificate course was the only course available for the metallurgical technician. Had there been a Technicians Certificate course, most of these students would have been better served by it. It is an indication of the slowness of pedagogical thought and experimentation to learn that it took from 1945 to 1965 to appraise the value of the Higher National Certificate and to underline the need for alternative courses.

A further imposition placed on the students was the requirement that they should pass each year of the Ordinary National Certificate course and each year of the Higher National Certificate course. The demands made on the students taking the City and Guilds Technicians Certificate are not so severe. The students may proceed in the non-certificate years at the discretion of the college. If this concession had been made a permissive feature of the National Certificate scheme, the frustration associated with repeating a year's study as a result of failure in one subject may have been eliminated and the high fall out rate may have been prevented.

The small number of students who were transferred from the four contributory centres to the main centre suggests a great waste in teaching power and indeed where a Regional Advisory Council examines the location of courses, it would have been wise to locate the entire provision in the main centre in order to give uniformity of standards and continuity of educational principles.

Further to the suggestion that the course should be localised in one centre, the records showed that 93% of the students were employed by five firms and involved in similar job specifications. These conditions would make for a closely integrated programme of training and education in which the student could see the industrialist and educator co-operating in his best interests.

3. Questionnaire and Interview

The final analysis of this survey was concerned with the observations of the students themselves.

The greatest criticism was concerned with the lack of metallurgical content in the course when the student begins his course of study at S1 and S2 level. The students were quick to make comparisons with other National Certificate courses and to point out that the metallurgical course was the only one that had not a direct relationship to the job at these levels.

The majority of students considered the course to be too academic and this may well be the case where the major portion of the students were employed in quality control occupations.

Again the greater proportion of students were of the opinion that there was insufficient time to assimilate the course content and this was associated with the question of subject usage on the job. The histograms of this section showed that much of the subject content, particularly in the ancillary subjects of chemistry, physics and mathematics were irrelevant to the main theme. It may be difficult for the educator to draw the line between those topics that constitute an academic exercise and what is real to the student. It must be the job of the educator to bring balance between what is theoretical and what is practical, what can be regarded as education and what passes for training and it must be his task to project his schemes of work to a point where their flexibility will provide a source of fundamental knowledge which can be applied long after the student has gained his college qualification.

The other major issue that emerged from the questionnaires and interviews was that many students had taken up a metallurgical career as a second best and felt no deep conviction about their study opportunities. The students who had had the opportunity to take up a research and development type of job felt a greater sense of purpose about the industry and a greater belonging to the industry than those in quality control and this made for a keener approach to their studies.

Recommendations

The factors that have been brought out as a result of the investigations in the three chapters concerned are important in making recommendations for any future scheme for the National Certificate in Metallurgy for Tees-side.

On the assumption that there is a place for the National Certificate in metallurgy and that it shall be the qualification needed by the higher technician grade it is important first to define the man and the job specification for the man and second to establish a programme of training and education to meet the needs of his environment.

One definition of a technician is as follows: "Between the levels of professional responsibility and craft skill there lies a wide range of work which calls for technical knowledge and manual skill in varying degrees. Those working in this range are described broadly as technicians"[50].

Undoubtedly the higher metallurgical technician will be more closely allied to the technologist than to the craft skills. He must have an understanding of his own technical field with the sciences and related studies forming disciplines of their own. At the same time his scientific and mathematical studies must be of an applied nature. He should be competent to apply proven techniques which are commonly understood by those who are expert in the branch of technology concerned. He should be able to diagnose practical problems, exercise his own skills in carrying out a task and act in a supervisory and advisory capacity to the lower technician, craftsman and operative. For these reasons it is essential that the technician's education shall equip him with, not only a sound foundation for his initial specialisms but such education in breadth as to endow him with that sense of adaptability to meet new and emerging problems.

The job specification for the majority of metallurgical technicians will involve chemical and physical techniques and the following duties may be ascribed to him:

(a) Sampling of materials.

(b) Chemical analysis of Ferrous and Non-ferrous metals, ores, fluxes, fuels, refractory materials and effluents by wet methods and spectroscope, polaragraph, X-rays and fluorescent techniques.

(c) The development of new methods of analysis by chemical and physical methods.

(d) Preparation of experimental alloys

(e) Heat treatment control

(f) Preparation and examination of metallographic specimens - micro and macro examination photography.

(g) Supervision of mechanical and non-destructive testing.

(h) Corrosion studies

(i) Measurement of physical properties

(j) Work's processes and quality control

(k) Correlation and evaluation of metallurgical reports.

In drawing up a scheme of work for a National Certificate in Metallurgy it is recommended that the syllabuses should stand in their own right and not be a part scheme with other courses of the pure and applied sciences[51]. Students would then begin to feel that their studies were being considered in the context of their work environment.

On the basis that the appropriate four passes of chemistry, physics, mathematics and English language in the General Certificate of Education or the satisfactory completion of the diagnostic General course in Science with credits in mathematics and at least one science - Physics, chemistry and a pass in the third shall be the entry qualification to the first year of National Certificate course, it is recommended that the following scheme would be an interesting solution in the educating of the Higher Technician. The scheme would be based on two years of part-time day study for the Ordinary National Certificate and two years of part-time day study for the Higher National Certificate with preferably two days of study per week or by block release to obviate evening attendance.

Ordinary National Certificate

Year I
- (a) Mathematics and Engineering Drawing I
- (b) Metallurgical Science I - Chemical
- (c) Metallurgical Science II - Physical
- (d) History of Metallurgical Technology and the Metallurgist in contemporary society.

Year II (a) Mathematics and Engineering Drawing II

(b) Engineering for metallurgists

(c) Fuels and Refractories

(d) Presentation and correlation of data.

Higher National Certificate

Year III (a) Extraction metallurgy I

(b) Physical metallurgy

(c) Mechanical and Thermal Treatment

(d) Science information and retrieval

Year IV (a) Extraction metallurgy II

(b) Physical metallurgy II

(c) Applied metallurgy

(d) Project

The scheme would be based on a minimum of 80 hours per subject. Emphasis would be placed on the continual assessment of the students' work and this would play an important role in the progress of the student from Year I to II and III to IV.

Syllabus Content

Mathematics and Engineering Drawing I

The mathematics and engineering drawing will be taught in such a way as to emphasise the effectiveness of these subjects as a tool in the hands of the metallurgist.

General

The use of tables, slide rule and calculating machines. The consideration of accuracy of numerical calculations.

Algebra

Revision of logarithmic calculations, natural logarithms, transposition of formulae involving ln x and exp x. The graphs of ln x and exp x.

Simultaneous equations in two unknowns (one linear and the other quadratic). Simultaneous linear equations in three or more unknowns.

Permutations and combinations as a lead to probability.

Binomial theorem; use in expansions and approximations.

Trigonometry

Circular measure, Definition of trigonometric functions of angles of any magnitude. The compound angle formulae.

Concept of inverse trigonometric functions.

Calculus

Derivatives

Rules for differentiating powers and polynomials. Derivatives of sines and consines. Simple maxima and minima.

Integration as the inverse of differentiation, simple application, idea of the integral as the limit of a sum.

Statistics

Definition of mean, variance and standard deviation and variance for small samples and grouped data.

Simple exercises in probability, binomial distribution. Idea of a set of actual observations as a sample from a much larger population. Distribution of means of samples from a normal distribution, standard error of the mean.

Analytical Geometry

Distance between two points. Equation of the straight line. Parallel and perpendicular lines.

Determination of laws from experimental data by reduction to linear form. Use of log-log and semi-log paper.

Graphs of functions, curve sketching in simple cases.

Engineering Drawing

Simple geometric constructions in plane and solid geometry. Simple intersections.

Pictorial (isometric and oblique) and orthographic projection.

Mathematics and Engineering Drawing II

Calculus

Rules for differentiating sums, products, quotients and function of a function. Derivative of e^x and $\ln x$. Approximations and small errors.

Application of integration - areas, work done by a force and expanding gas.

Application of partial derivatives to thermodynamics. Exact differentials. Differential equations, variables separable and linear:- examples from cooling, extraction and material testing.

Statistics

Measurement of probability in terms of relative frequency, additions and multiplication theorems.

Generalisation of Binomial, Poissonian and Normal

Distribution, theory and relevant examples.

Sampling:- concept of sampling, distribution of statistics, standard error of mean and proportion, tolerance limits, stratification in sampling.

Quality control, inspection sampling, sequential analysis in relation to binomial population.

Design of experiments in which results are assessed by analysis of variance. One and two factor variation, interpretation and interaction. Latin square arrangement. Chi-square tests with contingency tables. Scatter diagrams, principles of least squares and linear regression.

<u>Engineering Drawing</u>

Learning to understand an engineering drawing, principles of detailing and dimensioning (B.S.308) standard threads B.S.W. and B.S.F. (B.S.84), B.S.P. and B.A. limits and fits (B.S.1916 pt.2) Surface finish (B.S.1134). Simple sketching and selection of materials for engineering parts.

Metallurgical Science I

Theory

Physical Chemistry

Atomic Structure. Electron, proton, neutron, position, atomic number, mass number, isotopes, electronic arrangement, energy level, orbital spin, valency, periodic classification.

Bonding. Ionic, covalent and metallic, examples.

Chemical Equilibrium. Law of mass action. Factors affecting equilibrium, temperature, pressure and concentration. Le Chetelier's principle, distribution law, catalysis.

Electrochemistry. Electrolysis. Faraday's laws, conductance. Kohlrausch's law. Transport numbers, ionic mobility, dissociation. Descriptive treatment of electrode potential, oxidation and reduction.

Ionic Equilibrium. Ionic product of water pH scale solution, solubility product. Association constants, common ion effect. Buffer solutions. Theory of indicators, acid/base, redox.

Inorganic Chemistry The chemistry of the Transition elements and their comparison with non-Transition elements. Variable oxidation state, polarizing power, stereochemistry and ligand field theory, magneto-chemistry, absorption spectra, stabilization of oxidation states, metal-carbon bond.

Practical Work

Volumetric Analysis. Normality and molarity concepts, standard solutions. Volumetric analysis using methyl orange and phenol phthalein indicators. Volumetric analysis using $KMnO_4$, $K_2Cr_2O_7$, $Na_2S_2O_3$ and I_2 as standard solutions.

Qualitative Analysis Analysis of simple mixtures containing not more than four radials using classical tables of separation.

Metallurgical Science II

Theory

Heat and the Metallurgical Application of Temperature

Measurement of temperature, resistance thermometers. Types of pyrometers and their application, thermocouples, optical pyrometers.

Radiation. Black body conditions, theory of exchanges, Stefan's law, Radiation pyrometers.

Thermal conductivity, determination. Consideration of thermal conductivity in refractory and insulation material.

Heat transfer and fluid flow, conduction, convection and radiation as involved in metallurgical practice, calculations.

Light. The nature of light waves. Production and detection of plane polarised light waves.

Interference, coherent sources, Young's experiment, Fresnel's biprism, thin films and applications, Newton rings. Diffraction grating.

Metallurgical microscope. reflected, incident and polarised light. Phase contrast. Photomicrography.

Properties of Matter. Simple explanation of the phenomenon of surface tension. Free surface energy. Excess pressure in spherical drops and bubbles. Angle of contact.

Spreading of liquids and the wetting of solids. Capillary rise. Viscosity, Poisenille's and Stoke's formulae for streamline flow.

Stoke's law. Sieving and settlement of particles (i.e. elutriators, classifiers and settlers). Effect of particle size distribution on basic properties of packed material.

Electrical and Magnetic Properties of Materials

Conductors, insulators and semi conductors. The influence of impurity atoms on conductivity. Para, di- and ferro-magnetism, domain theory, hard and soft magnetic materials.

Practical

Heat transfer - gas/air or flame/gas or flame/water or steam/water.

The calibration and the use of pyrometers.

The metallurgical microscope - polarised light and phase contrast equipment.

Screen sizing and graphical representation of simple and cumulative percentages and the fineness number of the mass.

Elutriators

Calibration of flowmeters

Determination of Reynold's numbers

Heat transfer and Thermal Conductivity experiments for good and bad conductors.

Engineering for Metallurgists

Mechanical Engineering

Simple bending, bending moments. Stress calculations relating to the bending of beams of symmetrical section and torsion of circular shafts.

Analysis of stress, normal stress, Basic assumptions made by the engineer, e.g. uniform distribution of stress. Shear stress, principal stresses, principal planes, planes of maximum Shear. Analysis of strain, normal strain, Shear strain and principal strains. Elements of strain gauge analysis and its application. Mechanical testing. Normal mechanical tests - tensile, elasticity and plasticity Hardness notched bar, creep and fatigue, compression, transverse and torsion. Non-destructive tests. The interpretation of test data and its use in prescribing limitation to manufacturing processes.

Electrical Engineering

Units. Introduction to basic D.C. and A.C. theory. Elements of motor and generator, transformer and rectifier circuits and their construction.

Electronics: Basic treatment of semi-conductors, diode and transistor.

Instrumentation - Basic principles of moving coil and moving iron instruments, C.R.O. Control instruments used in the metallurgical industry.

Elementary treatment of induction - heating effects.

Elementary treatment of electric arcs - characteristics, ionisation, voltage, heating effects, current surge and rectification.

Electrolysis and Electrolytic extraction - Electrolyte, deposition potential, Current density, effects of temperature.

This syllabus should be augmented by demonstrations and experimentation where appropriate.

Fuels and Refractories.

Fuels

Theory of combustion - Ignition temperature and limits, flame speeds. Heat losses. Heat balance. Combustion calculations. Outline of fuels used in metallurgical processes - solid, liquid and gaseous.

Coals, properties and laboratory testing, classification, industrial fuels derived from coals, high temperature carbonisation. Use of pulverized fuels.

Gasification, composition and properties of town gas, coke oven gas, producer gas, blast furnace gas. Gas burners. Liquid fuels, preparation and properties.

Oil burners. Types and characteristics of industrial and metallurgical furnaces. Heat release and heat transfer. Heat recovery - recuperators regenerators and wasteheat boilers. Economics of waste heat recovery.

Refractories

Definition of a refractory, ideal properties and reasons for deviation from ideal. Laboratory testing. Phase diagrams. Commercial refractories - raw materials, grading, bonding and manufacturing processes. Chemical and mineralogical changes during drying and firing of silica, fireclay, dolomite, magnesite and chrome magnesite and carbon. Behaviour of refractories in service, selection and economic considerations.

This syllabus should be augmented by demonstration and laboratory work where appropriate.

Extraction Metallurgy I

Thermodynamics Energy, conservation of energy, enthalpy, heat of formation. First law of thermodynamics, Kirchhoff's equation, heat capacity, concept of maximum work and reversible processes. Second law; entropy, free energy, Gibbs-Helmholtz, Clausius-Clapeyron, isochore, isotherm.

Principles of Ore-dressing

Comminution, classification, sizing, concentrating by jigging, heavy media separation, tabling, flotation, magnetic and electrostatic processes. Settling and filtration.

Principles of Pyrometallurgy

Drying, roasting, sintering, calcining and pelletising. Iron blast furnace. - physico-chemical principles of iron blast reactions, mass and heat balances. Direct and indirect reduction. Heat transfer and thermal gradients. Gruner theorem and critical hearth temperature theory. Gas flow and pressure drop. Blast properties and furnace operation, fuel injector. Slag formation, properties of slags, slag-metal reactions, activities of FeO, CaO, Sio_2 and P_2O_5.

Extraction Metallurgy II

Oxidation refining processes with reference to steel making processes. Physical chemistry and the physics of gas-slag, gas metal and slag-metal reactions.

Principles of deoxidation.

Steel making processes, review of processes and the factors determining the choice of a particular process. Physico-chemical principles underlying refining with reference to carbon, silicon, manganese, sulphur and phosphorus and their removal in open hearth, Bessemer, L.D., Kaldo and Rotor processes. Electric steel making. Manufacture of low alloy steels. Physico-chemical principles of stainless steel production.

Physical Metallurgy I

Theory

Crystal symmetry of metal structures, crystal systems and space lattices. Indices for notation of planes and directions. Diffraction theory. Bragg Law. diffraction patterns.

The solidification of pure metals.

Phase rule and methods of following a phase change, thermal analysis, dilatometric, electrical, magnetic and X-ray diffraction techniques.

Equilibrium diagrams of binary metals and alloys, factors governing the formation of solid solutions - size factor, effect of valency and electron concentration, substitutional, interstitial and ordered solutions, intermetallic compounds, eutectic and eutectoid, peritectic systems with examples from industrial alloys.

Introduction to ternary alloy systems.

Non-equilibrium cooling and its effect upon the phase diagram. Cast structures, coring. Diffusion, effects of temperature concentration and structure. Segregation. Deformation of crystal structure, plastic deformation slip, twinning, work-hardening. Differences between single crystals and polycrystals. Recrystallisation. Homogenisation and grain growth. Quenching, tempering and ageing effects.

Practical

Macro-etching, pre paration of small castings and examination of macro-structure, sulphur printing.

Preparation and examination of microsections of pure metals.

Methods of investigating equilibrium diagrams, cooling curves, dilatometry and quenching methods. Preparation and examination of microsections of solid solutions, cast and annealed, Widmanstatten structures, eutectic and peritectic alloys.

Effect of cold working and annealing on micro-structure to show slip and twinning.

Physical Metallurgy II

Theory

Nucleation and grain growth, application to grain growth, precipitation from solid solutions, precipitation hardening. The iron-carbon equilibrium diagram. Eutectoid transformation, isothermal and continuous cooling curves. Decomposition of Austenite. Martensite transformation, decomposition of martensite in steel. The structure, properties and application of plain carbon steel. Heat treatment of steel by annealing, normalising, quenching and tempering.

Introduction to the effects of alloying elements in steel.

Principles of case hardening by carburising and nitriding. Structure, properties and application of cast iron - high duty, acicular, nodular and malleable irons. A survey of the industrial non-ferrous alloy types, their structure, properties and application.

<u>Practical</u>

Quenching and tempering of steels.

Isothermal transformation diagrams.

Hardenability and end quench techniques.

The use of mechanical test in transformation experiments.

Examination of the following microstructures.

Plain carbon steels - slowly cooled and heat treated to show types of structures, alloy steels to show the effects of alloying on structures.

Cast irons.

Copper alloys, Cu-Zi, Cu-Su, Cu-Al, Cu-Ni, Cu-Si.

Aluminium alloys Al-Si, Al-Cu.

Bearing metals and solders.

Thermal and Mechanical Treatment

Deformation and elastic deformation. Simulator test to determine plastic characteristics. Effects of elastic deformation during working.

The working of metals by rolling, forging, drawing, extrusion, stamping, pressing and spinning. The application and limitations of these processes.

The effects of mechanical working on the structure and physical properties of metals and alloys, grain size and preferred orientation.

Types of furnaces used for soaking, reheating and heat treatment of metals and alloys. Batch, continuous and semi-continuous furnaces. Furnace design, construction and features affecting heat transfer. Liquid baths, solid, oil and gas fired furnaces, electric heating, radiant tubes and induction heating. Advantages and disadvantages of fuel firing versus electric heating. Furnace atmospheres and their control.

Heat treatment of plain carbon and alloy steels including high speed steels. Principles and techniques of surface hardening.

Considerations of residual stresses, distortion and cracking as a result of heat treatment and mechanical working processes. Quality control of products.

Applied Metallurgy

Welding

Thermal effects, factors affecting heat requirements. Heat transfer to and through the material. Thermal distribution achieved in the material, physical properties governing thermal distribution. Modification to Fe/C diagram due to the effects of rapid cooling. Effects of alloying elements. Structure of heat-affected zones for single and multi-run welds. Effects of cutting and gouging.

Control and correction of distortion. Stress relieving. Weldability and weldability tests and assessments. Electrodes and fluxes.

Types of welding process, gas welding, metal arc welding. Inert gas and metal consumable gas-shielded welding. Submerged arc welding. Electro slag welding.

Spot seam, projection, butt and flash-butt welding processes. Weld defects and their causes.

Thermal cutting techniques.

Principles of brazing and soldering.

Testing and Inspection by destructive and non-destructive testing.

<u>Corrosion and Surface Treatment</u>

Electro-chemical series, electro-chemical corrosion.

Hydrogen oven-potential.

Oxygen diffusion and polarisation. Passivity.

Effects of partial and total immersion.

Nature and effect of corrosion product on corrosion.

Stress corrosion, corrosion fatigue.

Inhibitors and their use.

Electrodeposition from aqueous solution. Plating solutions and additives. Pickling, cleaning, etching and polishing as properties of electrodeposition.

Basic technology of electrodeposition of metals.

Principles of hot dipping, galvanising and tinning.

Metal spraying, properties and uses of sprayed surfaces.

Anodizing of aluminium and its alloys.

Phosphate and chrome coatings.

History of Metallurgical Technology and the Metallurgist in Contemporary Society.

Influence of metallurgical discovery and invention upon the Ancient World, economic, military, social. Copper, Tin, Bronze, Iron[52].

Medieval metallurgy. 10th Century - extension of mines and sites beyond the former Roman Empire. Use of coal for preliminary operations with charcoal for smelting. Application of water-power, bellows, hammers, stamping mills.

Metallurgy of all metals except iron virtually undeveloped until 16th Century.

Techniques. Wire by forging until 10th Century, invention of draw-plate, water-power used for wire drawing 14th Century. Steel production from Roman period by shaft furnaces using spathic iron.

Cementation process and wrought iron.

Industrial Revolution - development of machines, growth military technology.

1735 Darby succeeded in smelting iron with coke instead of charcoal[53].

1784 Cort's puddling process

Influence of machinery, locomotion and steam engine on metallurgical techniques e.g. Maudslay's lathe, Nasmyth's steam hammer, Bessemer, Siemens, Gas and arc welding[54].

Metallurgist in contemporary society. Transition from "metalsmith" or craftsman to a scientist engaged in team work with other material technologists.

Contribution to mass production of consumer durables,

e.g. automobiles, domestic appliances

and capital goods

e.g. aircraft, engines, space vehicles.

Presentation and Correlation of Data

Report writing. Reports for two purposes: (1) To convey information to others working in the same or related field (2) to supply information upon which executive decisions may be made.

Method of Report Writing. - Information collection, observations, experiences and references. Organisation, the remit and plan to suit reader. Outline, discarding of irrelevant information, information selection and ordering. Form of language. Literary style undesirable. Sentence structure to give precise information and avoid ambiguity. Reference and Illustration - appendices.

<u>Information Science</u>

Literature searching, abstracting and classification.
Communication of knowledge.
Information gathering, through books, journals, libraries, research organisations and trade organisations. Method of locating sources and efficient use of them.
Storage and Retrieval - classification, card indexing, mechanical and computer methods of retrieval.
Dissemination of information. Communication, report writing, abstracting editing, printing, reprography, patent laws and copyright, liaison and advisory service.

Administration of Information Service - organisation and staffing of department, relationships with other services, library and research.

Project. In the final year the student will be expected to carry out a project which has been approved by both his employer and the college and will be of the nature that it has bearing on his job in industry. College staff will be expected to so guide his studies that both the metallurgical knowledge and the complementary study element are used in this project. It would be expected that part of the project would be conducted in industry and part in the college.

The course of study has been designed with a minimum of overlap between subjects but with the view of emphasising the interdependence of one subject on another and with the intention of showing a natural flow through the four years of the course.

It is to be remembered that the course is designed for students working in the Iron and Steel environment of Tees-side and that although the fundamental studies that the student will derive from this course will fit him to adapt himself to other metallurgical regions, the course does show some bias to the Iron and Steel industry.

In light of the foregoing observations it is recommended that for educational and economic grounds the course should be controlled within one centre and that the students should be members of the metallurgical department from the outset. This is not to say that chemists, physicists and mathematicians from other departments should not service the course, but rather let it be seen that there is a close integration between staff and between staff and employer so that the student would be made conscious of the effort being made on his behalf.

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