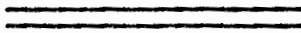


A FACTORIAL ANALYSIS OF STD VI  
and JUNIOR CERTIFICATE SUBJECTS.

A THESIS PRESENTED FOR THE DEGREE OF M.Sc.(PSYCHOLOGY) 1947.

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U.C.T.

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ACKNOWLEDGEMENT.

I wish to thank Mr. J.G. Taylor, the supervisor of this thesis, who was kind enough to render me every assistance in connection with the theoretical as well as the practical side of the work.

I am indebted also to the following people with whom I had discussions during the course of the investigation:

Professor H.A. Reyburn, who kindly offered assistance and guidance, Professor W.F. Grant, Professor J.F. Burger, Dr. E.M. Thompson, Dr. Strasheim, Mr. Caldwell, Mr. Swart, the inspectors of the school circuits and, finally, the principals of the schools concerned. Both these must, however, remain anonymous for reasons of security.

My special thanks are also due to my wife, who helped with the statistical work, the bibliography, etc. and read the script before being typed.

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## SUMMARY.

In this investigation a factorial analysis was made of Std VI and Junior Certificate subjects with the special aim of finding out which factors enter into aptitude for Science and Mathematics. The term science here means particularly Physics and Chemistry.

The data used were the Cape departmental examination results for Std VI (1942) and Std VIII (1944). A group of boys were chosen who had been in the same class in Std VI and then moved over to the same Std VIII class two years later. Two groups were chosen from two schools respectively making a total of 120 cases (boys).

The subjects chosen can be classified under the headings Language, Science and Mathematical.

Intercorrelations were worked out between the eleven variables chosen of which six were Std VI subjects and four came from Std VIII. The date of birth was also included.

The correlation table was then factorised using the centroid method. Three factors were isolated before the median of the residual correlations fell below the average probable error. The presence of a fourth factor was, however, indicated by other considerations and another factor was extracted.

The rotation of the centroid matrix was then carried out by hypothesis. In this the solution was retained which produced factors which could be recognised and agreed with the principles of common sense.

The following names are suggestive of the nature of these factors. Their real meaning will, however, only become clear after reading the full description in the text. The stroke above the roman figure indicates that the factor has been rotated.

Factor I : Insight. (a fairly general factor).

Factor II' : Memory. (a group factor).

Factor III'' : Language. (a group factor).

Factor IV' : Flexibility in accordance with rules. (Mental manipulation).  
(a group factor).

As far as the school subjects were concerned it was found that in Science (physics Chemistry and Biology) and problem Arithmetic the most

In Mathematics and Mechanical Arithmetic again, the important factor was IV' Flexibility in accordance with rules, closely followed by the factor "Insight".

Of all the subjects the ability involved in Biology appears to be the nearest approach to a so-called unitary trait which in this case is factor I'. This must, however, be qualified by pointing out that this is only so far as one has to account for the individual differences in this subject. It does not mean, for instance, that it is possible to succeed in Biology with a memory ability at the hypothetical absolute zero. At this stage however, everyone appears to have the minimum required.

As regards the prospects for differential forecasting at the end of Std VI, the indications are that difficulty will be experienced when, for instance, a separation of the literary from the mathematical pupils are attempted. English (total) and Mathematics, both Junior Certificate subjects, depend on "Insight" to the extent of over 30% of the variance.

The differential prediction of Science appears to be more hopeful at this stage. The chief factor involved is "Insight", and it is here twice as important as in the case of English.

It appears strange that Mathematics, which requires a strong "special ability" (factor IV') can offer difficulty at this stage. This is however due to the fact that factor IV' is still very uncertain. It was extracted from residual correlations which were already below the average probable error.

#### CONCLUSION.

The following are the main conclusions of this investigation:

- (1) At Standard VI pupils can definitely be separated into
  - (a) The academic "type" ~~and~~ (type used in the popular sense)
  - (b) Those whose abilities allow only memorising work to be done.
- (2) There is a general factor (intellectual), <sup>or "Insight"</sup> in the academic subjects which makes it difficult to effect a separation of pupils on the basis of the separate abilities involved.
- (3) That these special abilities definitely exist but that Std VI is a bit too early for a decision depending on the special ability involved in Mathematics.
- (4) In Std VI a combination of Mechanical Arithmetic and Problem Arithmetic promises to have a high predictive value for success in the Junior

Certificate subject ~~P~~hysics and ~~C~~hemistry.

(5) A weighted combination, of Mechanical Arithmetic and problem Arithmetic with the emphasis on the first mentioned will correlate high with Mathematics in Junior Certificate.

---

THE RELATION OF SCHOOL SUBJECTS TO GENERAL INTELLIGENCE.

Science subjects appear to be largely dependant on only one of the factors in "General Intelligence" and therefore not affected by variations in the other components.

● This hypothesis would be in line with the findings of Dr. E.M. Thompson<sup>1</sup> who studied the factors affecting school success in Std VII and Std IX.

"General Intelligence" was found to be important in both English and Mathematics and in the order stated.

Success in Physical Science (Std VII) however, depended to a limited extent on "General Intelligence" and this dependance became negligible by the time Std X is reached.

In the case of Biology (Std VII), it was found that "General Intelligence" constituted one of the less important factors determining success in this subject.

● The finding of the present thesis that scientific subjects tend to be largely dependant on a unitary trait is similar also to the conclusions of J.M. Earle (3, pp45-46) who found, inter alia, that in the third year of high school Science correlated positively only with Analogies and Reasoning tests; the correlations being .29 and .43 respectively.

---

<sup>1</sup>

Dr. E.M. Thompson: "Factors affecting School Success"

(Unpublished Doctors Thesis University of Cape Town). 1943. pp 109-119.

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INTRODUCTION.

Statement of the problem.

When a pupil finishes with the primary school and begins with secondary school he reaches an important stage in the ultimate choice of a career. It would be of practical value to know if it were possible to give educational guidance at this stage.

The general problem selected at the start, was the prediction of Scientific and Mathematical ability at Std VI level. As a preliminary to this, it was decided to make a factor analysis of Std VI and J. C. subjects in order to determine which factors, operating at this stage, produce the individual differences in the examination results. The determination of these factors and their relative importance in the ultimate result - the pupils exam results in a particular subject - will then be the immediate problem of this thesis.

In the strict academic sense this thesis can also be regarded as testing out the following hypothesis:

- (a) All the correlations between the school subjects can be explained by a general factor plus group factors.
- (b) All the factors have a positive influence
- (c) All the factors are independant of one another. (Mathematically this means that the axes in the rotated matrix must be orthogonal).

The above sub-divisions must, however, not be regarded as alternative; they all belong to the major hypothesis No. (3) given in the next chapter.

The outcome of this theoretical question will ofcourse have its practical implication. The possibility of differential educational guidance at StdVI level will to a great extent depend on the importance of special or group factors in relation to a general factor.

Work already done on the subject.

The Encyclopedia for Educational Research (13)<sup>1</sup> sums up the results achieved in connection with the isolation of special abilities, and can be taken as representative of what has been done in America up to 1941.

Easley (op. at p. 167) under the subheading "Special Abilities" in School Subjects" states that research findings have not revealed the origin and nature of special abilities and their relation to general ability.

STANDARD VI.  
(FIRST LANGUAGE) (I)  
EXAMINATION PAPER

1022]

DEPARTMENT OF PUBLIC EDUCATION.  
CAPE OF GOOD HOPE.

Above each answer copy the number of the question from the examination paper.

- 1. (i) We use phrases such as "safe and sound"; "bale and hearty".  
Complete the following:—  
(a) Odds and.....  
(b) Ways and.....  
(c) Teeth and.....  
(d) Fits and.....  
(e) .....and dry.  
(f) .....and wane.  
(g) .....and open.  
(h) .....and go. [8]
- (ii) Write down for each of the following groups of words ONE word with the same meaning. Example: *counting every year*—annually.  
(a) *over and over again*.  
(b) *without any delay*.  
(c) *not lawfully*.  
(d) *cannot be seen*.  
(e) *liked by everybody*.  
(f) *exactly to time*.  
(g) *now and again*.  
(h) *has no smell*. [8]

- 2. (i) Write down the subordinate clause in each of the following sentences and give its kind and relation:—  
(a) The stranger showed us where we should find a path across the fields.  
(b) We knew the time when the signal would be given.  
(c) The airman was very tired when he completed his flight. [9]

Make the following group of sentences into a complex sentence by using suitable conjunctions and making any other alterations necessary.  
She is a charming woman.  
She is a teardrop in human shape  
I cannot make up my mind. [3]

Rewrite the following sentences putting a subordinate clause in the place of the phrases in italics:  
(a) Under the belief that death was near he spent money lavishly.  
(b) He told his parents *his intention*. [4]

Write down:

- (a) opposites to: respectful, capable, understand, bravery.
- (b) adverbs corresponding to: fame, anger.
- (c) adjectives corresponding to: gold, trouble, reason.
- (d) verbs corresponding to: rich, pure, description.
- (e) nouns corresponding to: strong, agree, wise, prove. [16]

3. (a) Rewrite the following passage in Direct Speech:  
The chairman said that he could not let that great audience suspect that he had no replies to those difficult questions, and he would therefore devote some time to explanations that would satisfy them. [5]

(b) Change the following passage into Indirect Speech:  
"Will it be expecting too much of you", inquired the teacher of his pupils, "if I ask you now to behave yourselves as heroes when your parents will be in the school building?" [5]

Six sentences are given below. These six sentences, if arranged in their proper order, would make a short story. Write the sentences down in their proper order, numbering them 1, 2, 3, 4, 5, 6.

- 1. Each of them went to find a weapon.
- 2. Each animal was selfish and wanted the whole field for himself.
- 3. Just then a hawk swooped down and swallowed them both.
- 4. A frog and a mouse once lived in the same field.
- 5. Armed with the sharp point of a hairbrush, they faced
- 6. The hawk.

(d) Put the following into indirect speech. Your answer should be in one paragraph, and it should read like an extract from a well-written story. You may make what changes you think necessary:—

"Do stop that sniffing, Robert. And why do you think it necessary to kick the table leg!" said Mr. Wilson to his son as they sat at breakfast.  
"Sorry, Father. I want to ask you something".  
"What?"  
"You haven't given me this month's pocket-money yet. May I have it today?"  
"Pocket-money! Didn't I give you ten shillings for your birthday?"  
"I've spent it all, and my next allowance is due now".  
"I cannot give it to you before tomorrow". [15] [40]

- 5. (a) Answer Yes or No to the following questions:—  
(i) Does an anniversary occur more than once?  
(ii) Do people who do manual labour work with their hands?  
(iii) Is the health of a convalescent improving?  
(iv) Are fish kept in an aviary?  
(v) When a ship is adrift, is it continuing on its course?  
(vi) Is stubborn resistance easily overcome?  
(vii) If you wanted to be able to rub out work if necessary, would you use an indelible pencil?  
(viii) Has a veteran had experience?  
(ix) Are the eaves part of the floor of a building?  
(x) Is a candidate who comes to an examination with moustaches pinned on his clothing superstitious? [10]

(b) Use any SIX of the following words in sentences in such a way as to show you understand their meanings:—  
lag, prolonged, indolence, allay, edition, doveally, eave-drop, tidings, picture. [12]

(c) Write down the numbers 1 to 8 in your answer-book. Below are given, first, the meaning of a word, and then the first and last letters of that word. Write down each word in full. Make sure that your spelling is correct:

- (i) Exactly to time..... pun . . . . 1.
- (ii) Competent..... effle . . . . 1.
- (iii) A place for storing water..... res . . . . r.
- (iv) Making light, or less heavy..... light . . . . p.
- (v) A bird's feather..... pl . . . . re.
- (vi) Very plentiful..... ab . . . . t.
- (vii) A table of days, months, etc..... cal . . . . r.

(2)

G.P. 6.20662-1943-3-3,000.

STANDARD VI.  
ENGLISH.  
(FIRST LANGUAGE.)  
SPELLING.

191. 1942.]

[20 minutes.]

1942.]

DEPARTMENT OF PUBLIC EDUCATION.  
CAPE OF GOOD HOPE.

The words should be given in short sentences to ensure their recognition, but the candidates should write the words only. No word is to be repeated more than twice.

- |                  |                   |
|------------------|-------------------|
| (1) Patrol.      | (14) Woolly.      |
| (2) Campaign.    | (15) Governor.    |
| (3) Mechanised.  | (16) Successful.  |
| (4) Vehicles.    | (17) Deceitfully. |
| (5) Achieve.     | (18) Challenge.   |
| (6) Resources.   | (19) Develop.     |
| (7) Agreeable.   | (20) Disguise.    |
| (8) Disappear.   | (21) Especially.  |
| (9) Knuckle.     | (22) Soothe.      |
| (10) Mosles.     | (23) Envelope.    |
| (11) February.   | (24) Courageous.  |
| (12) Chimney.    | (25) Condemn.     |
| (13) Exhaustion. |                   |

Deduct one mark for each error.

STANDARD VI.  
GEOGRAPHY.

(3)

G.P. 6.50472-1943-3-30,000.

187.

[1 hour.]

DEPARTMENT OF PUBLIC EDUCATION.  
CAPE OF GOOD HOPE.

- 1-5. Name the towns marked 1 to 5 on the attached map.
6. Name the province in which the town marked 1 is situated.
7. Name the kinds of fruit that are grown in this province.
- 8-9. Name the most important product of the province (8) Alberta, (9) Manitoba.
10. Name a town in Canada in which a large proportion of the inhabitants speak French.
11. Write the letter P on the map to indicate where Chile salt-petre is found.
12. Indicate by the letter K on the attached map where the most coffee is produced.
- 13-15. Name the towns marked 13 to 15 on the map.
16. Name the capital of the island marked A on the map.
17. Name the most important town on the island marked B on the map.
18. Indicate by means of arrows on the map the direction of the winter winds along the South coast of Australia and mark them with the letter W.
19. Indicate by means of arrows on the map the direction of the summer winds along the South coast of Australia and mark them with the letter S.
20. With what climatic condition have the inland farmers of Australia to cope?
21. What animal is the great enemy of the sheep farmer in Australia?
22. Name the most important product exported from New Zealand.
23. Name the mountain range in South Island.
24. What hard wood tree grows in New Zealand?
- 25-28. Name the towns marked 25 to 28 on the map.
29. Name the large river in the neighbourhood of the town marked (27).
30. Indicate by means of arrows on the map the direction of the winds in the cool season in India.
31. Name the important cereal grown in the marshes along the Indian rivers.

[20]

2

32. Name the most important product of the Deccan.
33. What grain is grown along the Indus?
34. What is the religion of the majority of the inhabitants of India?
35. At the mouth of which river is the town (28)?
36. Name the ocean current which warms the coast of Japan.
- 37-40. Name the seaports marked 37 to 40 on the map.
41. Write the name of the lake at the source of the White Nile.
42. Name the other great tributary of the Nile.
43. What is the chief grain grown in Anglo-Egyptian Sudan?
44. What export brings the most money to the Union of South Africa?
45. Name the most important agricultural product exported from South Africa.
46. Name the most important agricultural product exported from Australia.
- 47-51. What kind of farming is carried on in the districts (47) Malmesbury; (48) Paarl; (49) Prieska; (50) Vryburg; (51) Barberton?
- 52-55. Name the islands marked C, D, E and F on the map.
- 56-57. What products are imported into the Union of South Africa from the island C. and the island D?
58. What is the most important product of the island E?
59. What is the most important industry on the island F?
60. What kind of fruit is grown on the island A?
61. What is the distance round the earth at the equator?
62. If it is 12 o'clock (noon) in London, what is the time in the town 28 (120° E.)?
63. If it is 2 p.m. in Leningrad (30° E.) what is the time in Pietermaritzburg (30° E.)?
- 64-65. On which two days of the year is the sun directly overhead at the equator?
66. What is the name of the instrument by means of which pressure of air is measured?
67. What change will you see on this instrument when rain threatens?
68. What instrument is used for registering the highest temperature during the day and the lowest during the night?
69. With what instrument does the navigator determine his direction?
70. What is the freezing point of water on the Fahrenheit thermometer?

(4)

188.

[One hour.]

DEPARTMENT OF PUBLIC EDUCATION. CAPE OF GOOD HOPE.

Below are given (a) a list of events and (b) a list of dates. Write the numbers (1-8) one below the other, and write the correct date opposite each number. You must not write down the event.

- (a) (1) The first occupation of the Cape by England. (2) The elevation of Simon van der Stel to the rank of Governor. (3) The Sluiter's Nek Rebellion. (4) Basutoland becomes a Crown Colony. (5) Natal becomes a Republic. (6) Houtman's expedition to the East. (7) The wreck of the Staverisus. (8) The recognition of the independence of the Orange Free State. (b) 1834; 1840; 1895; 1795; 1816; 1686; 1690; 1844

1. Write the numbers (9-15) one below the other and next to each number, the answer.

- (9) What body must sanction the ordinances passed by the Provincial Council before they can come into force? (10) What body makes provision for the expenditure in connection with primary and secondary education? (11) What Native chief gave much trouble to the farmers of the Orange Free State? (12) Who was the leader of the raid on the Transvaal in 1895? (13) Who was the first Prime Minister of the Union of South Africa? (14) Who reversed Sir Benjamin D'Urban's Native policy in 1834? (15) Who published the first newspaper in South Africa?

... choose from among the names sets the one which will make the statement ... down only the correct name, opposite to the of the question.

- (16) (van Plettenberg, Ryk Tulbagh, W. A. van der Stel) has been called "The Father of the Trek Boer". (17) The first attempt to unify the different states in South Africa was made by (Sir Harry Smith, Lord Carnarvon, Sir George Grey). (18) The Chairman of the National Convention held in Durban in 1908 was (Cecil Rhodes, John Merriman, Lord de Villiers). (19) The first President of the Orange Free State was (Hoffman, Brand, Pretorius). (20) The building of the Castle at Cape Town was commenced by (John Bux, Isbrand Goske, Swellengrebel). (21) The majority of the Huguenots settled in the district of (Stellebosch, Paarl, Tulbagh). (22) The Fish River was declared to be the eastern boundary of the Cape Colony during the rule of (van Plettenberg, Father Tulbagh, Lord Charles Somerset). (23) A hostile attitude towards the missionaries was caused by (Schmidt, Dr. Philip, Moffat). (24) The first schoolmaster of the children of the Hugenots was (Sybrand Mankadan, Pierre Simond, Paul Roux). (25) (Panda, Dinizulu, Cetwayo) was the last King of Zululand.

26. Write from 15-20 lines on ONE of the following:—

- (a) The Free burghers of 1657. (b) Tshaka and the rise of the Zulus. (c) The emancipation of the slaves.

27. Write a short essay of about 25 lines on ONE of the following:—

- (a) Lord Charles Somerset OR President Burgers. (b) The visit of the Lord of Mydrrecht to the Cape. (c) The decline of the Dutch East India Company.

(6)

71.

[Two hours and a half.]

DEPARTMENT OF PUBLIC EDUCATION. CAPE OF GOOD HOPE.

EXAMINER: Mrs. M. E. McKERRON, B.A. MODERATORS: { Mr. J. C. ROSS, M.A. Mr. P. J. v. D. WALT, B.A.

Write on the top of the front page of your answer-book, after the words "Subject of Examination"—

JUN. CERT. ENGLISH HIGHER (FIRST PAPER).

Above each answer write the number of the question.

N.B.—Candidates are reminded that they must satisfy the examiner in Section A as well as in the subject as a whole.

SECTION A.

1. Write a composition on ONE of the following subjects. (The composition should consist of 300-350 words, i.e. 40 lines):—

- (a) During the last holidays you found all your favourite spots overcrowded by the many visitors to your town or village. Describe one or more new places you discovered in your attempt to escape the crowd. (b) A photograph album. (c) Write a composition in which the following sentence is used:—"Had I known what lay the other side of the wall, I should have acted differently". You may introduce this sentence anywhere in your essay, but you must introduce it just as it stands. (d) A new pair of boots (or shoes). (e) Uncomfortable moments in my life. (Do not limit your composition to a single incident). (f) Mudflats Junction—1st February—three o'clock in the afternoon—103 degrees in the shade. [75]

2. Write ONE of the following letters. The letter must be in correct form, with heading and conclusion in full, and the body of the letter should consist of about 120 words, i.e. about 15 lines:—

- (a) You have recently had to make a difficult decision. Write to a friend telling him (or her) about it.

- (c) You are starting a sports club at your school. Write to a shop asking it to supply you with the goods you need at reduced prices. Give good reasons for your request for reduced prices. [25]

## SECTION B.

3. Give the substance of the following passage in your own words:—

Then silence falls. Yet hark! Not silence now;  
A murmurous sound steals softly on my ear,  
And closer steals. The leaves expectant bow,  
As murmur grows to torrent loud and clear.  
The heavens have opened, and the rain is here!

Poor barren veld! Lift up your parched lips,  
Unless perchance salvation comes too late.  
Not yours to drink in shallow measured sips,  
At this last hour, your cruel thirst to sate.  
Drink deep, drink long, poor veld, your need is great.

Lay bare your breast to these thick-falling spears,  
And if the old plant die, yet who shall grieve  
Its day is over, but in coming years  
Its seed a carpet for the veld shall weave.  
Where one has sown, another shall achieve.

Drink long, drink deep; 'tis with no niggard hand  
Your draught is poured, but flowing to the brim.  
From new-filled tarn that ripples to its strand,  
And busy stream soft-purling at its rim,  
Ascends in chorus one exultant hymn.

(Mary R. Boyd).

[30]

4. (a) Analyse into clauses, and state how each clause is related to the rest of the sentence:—

Unless the messenger who has now been sent across the rocky slope increases his pace, he will not accomplish what is wanted. (11)

- (b) State the part of speech of each of the words in italics in (a). (4)

- (c) Combine the following sentences into ONE complex sentence, with one main verb. Do not use *and* or *but*. You may use the sentences in any order you like, and you may make what changes you think necessary in order to produce a good English sentence:—

An accident occurred in the street.

I was in the street at the time.

The police arrived later.

They made inquiries.

I could not give them much information.

[10]

5. (a) Below are nine sentences. The first sentence is underlined. Two of the remaining eight sentences mean the same as the sentence underlined. Write down the two sentences.

Not a sound was to be heard.

Everybody was deaf.

All was silent.

How I love silence.

Sounds are difficult to hear.

Everything was hushed.

I did not make a sound.

Noises were seldom heard.

Could I hear a noise?

[6]

5. (b) The sentence on the left below is the first sentence of a composition. On the right below are six sentences in brackets. Two of these six could act as the second sentence in the composition. Write down the two sentences.

Mr. Smith is rich but unhappy.

Mr. Smith has three sons.  
Such men are to be pitied.  
A rich but unhappy man is Smith.  
Money is a wonderful thing.  
We cannot buy happiness.  
There are several kinds of money.

[6]

- (c) In each of the sentences below are five words in brackets. Write down from the words in brackets the one which you think is the best to use in each sentence:—

(1) I have not seen him (in, to, of, on, at) late.

(2) She is now able to be (in, out, well, down, over) and about.

(3) She is out and (along, round, away, up, through) the best scholar.

(4) Don't spend a penny (when, where, as, unless, but) you can afford to do so. [4]

6. (a) Punctuate the following passage carefully, introducing capital letters where necessary, and arranging it as it would be arranged in a book:—

have you seen my dog tim anywhere has lost so but i shouldnt worry about him if i were you hell come home again i cant help worrying about him hes still very young and i dont think he knows his way (10)

- (b) Each of the following words occurs in a well-known English proverb. Select any FIVE of the words, write out the proverb connected with each, and give the meaning of the proverb. You must give five different proverbs in all:—

broth, manager, Jack, worms, candle, iron, stitch, ice. (15)

- (c) Form five English words from the prefixes and roots given below. Each word should contain a prefix from Group A, and a root from Group B. Each prefix and each root should be used once only. Then give the meaning of the word formed in each a way as to show that you know the meaning of both prefix and root. (Example: Postscript—an addition written after the rest of the letter.) You need not do this again.

Group A.—post, trans, dis, super, inter, pro.

Group B.—mit, script, spect, rupt, pel, vice. (10)

- (d) Fill in the blank space in each of the following sentences with a single word opposite in meaning to the underlined word. You need not write out the whole sentence. Write only the word required.

(Example: This fence is high, but that is low).

(i) You may think it probable, but I think it \_\_\_\_\_

(ii) Though he ought to be generous, he is \_\_\_\_\_

(iii) He must either admit or \_\_\_\_\_ the charge.

(iv) The teacher is usually very strict, but sometimes he is \_\_\_\_\_

(v) These minute creatures are a very great contrast to the \_\_\_\_\_ creatures of prehistoric times. (6) [40]

DEPARTMENT OF PUBLIC EDUCATION.  
CAPE OF GOOD HOPE.

EXAMINERS: { MR. I. J. M. ARCHER, M.Sc.  
MR. J. J. DE KOCK, B.Sc., B.EDUC.  
MODERATOR: MR. S. J. MALHERBE, B.A.

Write on the front cover of your answer-book, after the words  
"Subject of Examination."

JUN. CERT. PHYSICS AND CHEMISTRY.

Above each answer write the number of the question.  
(Answer ALL the questions in Section A, TWO questions from Section B and  
TWO questions from Section C. Keep the answers in Section A together.)

SECTION A.

(2 Marks for each question).

- Express (a) 1.0203 kilometres, (b) 2 inches as centimetres.
- Arrange the following cubic measures from the largest to the smallest:—  
A litre, a gallon, a bottle.
- Which is the longer distance—  
(a) a yard or a metre;  
(b) the circumference of a circle or six times its radius?
- Complete: We may also refer to the C.G.S.- and F.P.S.-systems as ..... and ..... systems.
- Mention TWO uses of a barometer.
- State TWO conditions necessary for a chemical balance to be sensitive.
- Define the Law of the Lever.
- Make a sketch of the pedal gear of a bicycle and indicate the positions of the fulcrum, resistance and effort.
- Complete: A beam is balanced at its centre. If a boy A, weight 100 lb., sits on the beam 6 ft. from the centre, then a boy B,

In the following THREE questions, complete the statements:—

- ..... solids cause the freezing point of water to .....
- The ..... of a body is the number of calories required to raise the ..... of that body through 1° C.
- ..... is the passage of ..... from hotter to colder portions of a body.

Say whether these are physical or chemical changes in the next TWO questions:—

- (a) Sugar dissolves in water.  
(b) Water changes into ice.
- (a) Paraffin burns.  
(b) The surface of a planed pine board changes gradually in colour.
- Name (a) a physical, (b) a chemical property in which hydrogen differs considerably from oxygen.
- Correct the last part of the statement: To dissolve gases and solids more quickly in water, the water has to be distilled and evaporated respectively.

In the next TWO questions, name the substances formed if:—

- Sulphuric acid is added to a solution of Barium Chloride.
- Lead peroxide is heated on a charcoal block.
- Chemical reactions are classified under the following headings: neutralization, oxidation, simple chemical decomposition, double decomposition and displacement.  
Select the correct heading under which you would classify the reactions given in questions 17 and 18 and write them down in the correct order.
- Complete: A reducing agent is a substance which combines with ..... or liberates ..... readily.

Correct the statements in the next TWO questions. (Only the correct word or phrase may be written down):—

- (a) If moist iron filings are closely corked in a test tube, the iron filings combine with the oxygen and the tube with its contents gain in weight.  
(b) To cool the tube of a Liebig condenser, water must be made to run down the surrounding tube.
- (a) Calcium salts make water hard.  
(b) The properties of a physical mixture are the sum of the constituents.

The salts given under the next TWO questions are heated until no perceptible change can be seen. Name the products formed:—

- Crystals of washing soda.
- Chalk saltpetre.

SECTION B.

- (a) Explain the difference between *specific gravity* and the *density* of a substance.

Describe briefly how you would determine the specific gravity of glass in the shape of a fairly large marble. State possible readings (instead of W gm. etc.) which you may expect in this experiment and use them to calculate the specific gravity of glass. [12]

- (b) If you take the density of pure milk to be 1.03 gm. per cc., how would you test in the laboratory whether water was added to the milk which is delivered at your house? [5]
- (c) A specific gravity bottle filled with water weighs 60.5 gm. 40.8 gm. of mercury (S.G. = 13.6) is poured gently into the bottle so that some of the water in the bottle is displaced. Find the weight of the bottle together with the mercury and the remaining water in it. [8]

- (a) Explain the difference between *temperature* and *heat*.

You are supplied with a graduated Centigrade thermometer. Describe in detail, with the aid of a sketch (without retort stands), how you would proceed to test, without the aid of another thermometer, whether the boiling point on the thermometer is correct. [13]

- (b) Convert a reading of 35° C. into degrees Fahrenheit. [4]
- (c) Briefly explain the term atmospheric pressure.

Given that the barometer reading at sea level is 30 inches and that it drops 1 inch per 1,000 ft. Calculate—

- (i) the barometer reading at a place 2,500 ft. above sea level;
- (ii) the volume of the mercury column (in cu. ft.) in a barometer tube of 1 sq. in. cross-section, at the above-mentioned place;
- (iii) the atmospheric pressure in pounds on an area of 1 sq. inch at the above-mentioned place. S.G. of mercury is 13.6.  
(The answers may be left as unsimplified fractions.) [8]

- (a) Define *Archimedes' Principle* as applied to floating bodies. [3]

A small rectangular block of wood 10 cm. by 2 cm. by 2 cm. floats with  $\frac{1}{10}$  of its volume under water. Calculate the following:—

- (i) Volume of the block.
- (ii) Volume of water displaced by the block.
- (iii) Weight of the block.
- (iv) Density of the wood.
- (v) Additional weight required which would make the

(vi) The specific gravity of a solution of copper sulphate in which the block floats with  $\frac{2}{5}$  of its volume submerged. [12]

(b) Describe briefly, showing a sketch of the apparatus, how you would compare the conductivity of glass, iron and copper. State clearly what you observe. [10]

## SECTION C.

5. (a) Dry hydrogen is prepared from water and magnesium in such a way that the hydrogen which develops can be burned in air and the product which forms during combustion can be collected. Neatly sketch the whole apparatus (without retort stands) you would use to carry out this experiment. Name all the products formed. [13]

(b) (i) Mention a physical test and (ii) describe briefly a chemical test to prove that a given liquid is water. [5]

(c) Describe fully how you would prove that a given solution contains hydrochloric acid. [7]

6. (a) Describe an experiment, mentioning what you observe, you carried out to prepare and collect a number of cylinders full of dry carbonic acid gas. Sketch the apparatus and name the product formed in the generating flask. (4 marks for sketch.) [13]

(b) Three test-tubes labelled A, B and C contain powdered calcium carbonate, slaked lime and quicklime; but the order in which the test-tubes contain these substances is unknown. How would you determine what each test-tube contains?

(Begin this question as follows and test the contents of each tube fully: Take three test-tubes, put a little of A into the first test-tube, a little of B into the second test-tube and a little of C into the third . . . .) [12]

7. (a) Describe *carefully* how you would prepare dry crystals of a salt by neutralising 2 gm. Sodium carbonate with sulphuric acid. What is the name of the salt? [12]

(b) Name THREE other methods to prepare soluble salts. [3]

(c) Supply the missing words in the following passage:—

Magnesium burns in air with a ..... flame forming a ..... powder called ..... When stirred up with water, this powder gradually dissolves forming ..... Litmus paper turns ..... in colour in this solution, showing that ..... is formed. Most metallic oxides are .....; those which are soluble in water form ..... Most non-metals form ..... oxides, though a few, such as ..... form oxides neutral to litmus. [10]

1944.]

(8)

85.

TWO hours.

## DEPARTMENT OF PUBLIC EDUCATION.

## CAPE OF GOOD HOPE.

EXAMINERS: { DR. H. E. BRINK.  
MR. H. S. H. WEICH, B.A., B.Sc., B.Ed.  
MODERATOR: MR. D. C. SWART, M.Sc. AGRIC.

Write on the front cover of your answer-book, after the words  
"Subject of Examination"—

## JUN. CERT. BIOLOGY.

Above each answer write the number of the question.

(N.B.—Answer FIVE questions, choosing TWO from Section A, TWO from Section B and ONE from Section C.)

## SECTION A.

1. (a) Compare briefly the characteristics of sandy and clayey soil with regard to aeration, water capacity and texture. [12]

(b) Name THREE different kinds of manures (fertilizers) that are applied to soils, and mention for each case one plant-food that it supplies to the soil. [6]

(c) With what part of the root does the plant absorb mineral salts and water from the soil? How are these soil-constituents taken up? [4]

(d) Make a fully-labelled sketch to show the different parts of the tip of a root. [8] [30]

2. (a) What is transpiration and how does it benefit the plant? [6]

(b) State briefly how you would prove that the leaf of a plant transpires more on the one side than on the other. [8]

(c) Make a fully-labelled sketch of the apparatus you would use to prove that green plants or germinating seeds respire. Explain how you would prove that in this experiment oxygen was used up and carbon dioxide was given off. [16] [30]

3. (a) Describe the structure of a composite flower (e.g. a sunflower or a gousblom). Illustrate your answer by means of fully-labelled sketches. [20]

[P.T.O.]

(b) How are seeds dispersed by—

(i) wind, and

(ii) animals? [10] [30]

## SECTION B.

4. A. (a) Make a clear, fully-labelled sketch of the organs of excretion and reproduction of the female frog. [16]

(b) Describe in detail how you would dissect a frog so as to expose these organs. [8]

(c) What is meant by fertilisation? How does this process take place in the frog? [6] [30]

## OR,

4. B. Mention THREE insect pests which you have studied and answer the following questions about each:—

(i) Why are they of economic importance? [3]

(ii) During which stages do they cause most harm? [3]

(iii) Where do they lay their eggs? [3]

(iv) State whether they have a complete or an incomplete metamorphosis. [3]

(v) How many wings do they possess in the adult stage? [3]

(vi) What type of mouthparts do they possess in the adult stage? [3]

(vii) During which stage can they be controlled most easily? [3]

(viii) Describe in each case that measure of control which you consider most important. [9] [30]

5. (a) Why would you classify a spider as an Arachnid and not as an Insect? [12]

(b) Compare the earthworm and the millipede with regard to—

(i) respiration,

(ii) movement,

(iii) eyes. [6]

(c) Make a large, clear, fully-labelled sketch of any Mollusc which you have studied. [12] [30]

6. (a) Mention the classes of vertebrates of which the following are characteristics:—

(i) two condyles connecting the skull and the vertebral column.

(ii) a quadrate bone connecting the lower jaw to the skeleton.

- (iii) possess lungs but no diaphragm.  
 (iv) the eyes have two eyelids and a nictitating membrane.  
 (v) the heart is divided into one auricle and one ventricle. (10)
- (b) Compare the body-covering of the different classes of vertebrates. (10)
- (c) In the classification of the Class Mammals into different orders the structure and number of teeth are very important characteristics. Discuss this statement, giving examples. (10) [30]

## SECTION C.

7. Rewrite the following sentences in your answerbook, fill in the missing words and underline the words you have filled in.
- (1) The changes which frogs and ..... undergo in the course of their development are called .....
  - (2) When an alga and a fungus live together the phenomenon is known as ..... because ..... derive benefit from such an association.
  - (3) The living being which lives on another living being is called a ..... The living being which lives on the dead remains of another living being is called a .....
  - (4) If the flowers of the same plant have only stamens or only pistils, then the flowers are said to be ..... and the plant is said to be .....
  - (5) In the case of the bean the reserve food is found in the ..... and in the case of the mealie it is found in the .....
  - (6) By photosynthesis (carbon assimilation) is meant the formation of ..... from water and ..... in the ..... parts of the plant in the presence of .....
  - (7) The radicle is ..... geotropic, the plumule positively .....
  - (8) The brightly-coloured petals of a flower serve to ..... insects and in this way ..... is ensured.
  - (9) A ripened ovary is called a ..... and a ripened ovule is called a .....
  - (10) The frog breathes by moving its ..... up and down. The mammal breathes by moving its ..... up and down.
  - (11) Plants in a sickroom during the night are harmful because they give off ..... Waterplants are advantageous to water-animals because they give off .....

- (12) The ascent of water and mineral salts in the stem of a plant is brought about partly by ..... and partly by .....
  - (13) Amphibia represent a transition stage between ..... and ..... animals.
  - (14) A mollusc breathes by means of a ..... The tongue of the mollusc is covered with ..... [30]
8. Write short explanatory notes (not more than five lines each) on FIVE of the following:—
- (1) Sunlight is the supporter of all living beings.
  - (2) Adaptation to environment.
  - (3) The differences between living and non-living things.
  - (4) Classification of the plant kingdom.
  - (5) The formation of soil.
  - (6) The protection of plants against plant-eating animals. [30]
  - (7) Climbing plants.

JUNIOR CERTIFICATE.  
MATHEMATICS.

G.P. 8.31291—1944-5—6,100.

(9)

88.

1944.]

[Three hours.]

DEPARTMENT OF PUBLIC EDUCATION.  
CAPE OF GOOD HOPE.

Write on the top of the front page of your answer-book, after the words "Subject of Examination"—

## JUN. CERT. MATHEMATICS.

EXAMINER: MR. N. J. BASSON, B.A., B.Sc.

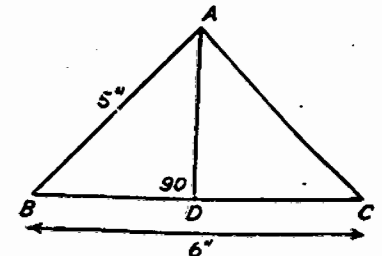
MODERATOR: MR. G. J. LOUW, B.A.

Above each answer write the number of the question.

(N.B.—All necessary work must be shown in its proper place with your answer. The left-hand page may be used for rough work.)

- (a) In S.A. we use morgen and miles to measure areas and distances. Which corresponding units are used in Europe? (2)
- (b) Express in centimetres: 5 dm. 3 cm. 7 mm. (3)
- (c) Give the difference (as a decimal) between the first and the second two in 17.232. (3)
- (d) Write down the answer to  $\frac{1.2 \times 1.75}{.012 \times 25}$ . (4)
- (e) £1. 1s. 0d. is divided in the ratio of 1:2:3. Calculate the smallest part. (4)
- (f) Find the square roots of  $\frac{50}{32}$  and  $\cdot 1$  (to 2 dec. places). (8) [25]

2. (a) In  $\triangle ABC$ ,  $AB = AC$ ,  $AB = 5''$ ,  $BC = 6''$  and  $AD$  is perpendicular to  $BC$ . Calculate the area of  $\triangle ABC$ . (12)



- (b) A circular piece of ground is 44 ft. in circumference. Calculate the cost to cover it with turf at 1s. 6d. a square yard. ( $\pi = 22$ ) (13) [25]

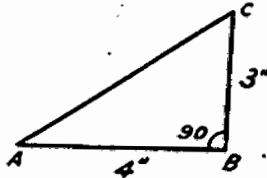
3. (a) If  $a = -2$  calculate the values of  $-(a)^2$ ,  $(-a)^2$ . (4)  
 (b) If  $+a$  represents the number of pounds I possess, what will  $-a$  represent? (2)  
 (c) Calculate the value of  $(a-b)(b-c)$  if  $a = 1$ ,  $b = 2$ ,  $c = -3$ . (4)  
 (d) Complete the following:  $\frac{p}{2q} = \frac{p^2}{\dots}$ . (2)  
 (e) By how much does  $x$  exceed  $y$ ? (2)  
 (f) What must be added to  $a - 2b - 3c$  to get zero? (2)  
 (g) A room is  $x$  yards long and  $y$  feet wide. Write down its area in square feet. (4)  
 (h) A horse can eat  $(3m + 2n)$  bushels of fodder per week. In how many weeks will it eat  $12m^2 - 7mn - 10n^2$  bushels of fodder? (4) [24]

4. (a) Solve for  $x$ :  $2x - \frac{2x-1}{3} = \frac{x+2}{2} + 6$ . (8)  
 (b) Solve for  $x$  and  $y$  in the simultaneous equations  
 $3x + 2y = -8$  and  $x - 6y = \dots$ . (8)  
 (c) Make  $S$  the subject of the formula  $V^2 = u^2 + 2fs$  and calculate the value of  $S$  if  $u = 5$ ,  $V = 3$ ,  $f = -4$ . (8) [24]

5. (a) Factorise:  $a^2 - b^2$ ,  
 $a^2 - 2ab - 3b^2$ ,  
 $3a + a^2 + 3b + ab$ .  
 Write down the L.C.M. and H.C.F. of these three expressions. (11)  
 (b) Simplify:  $\frac{x^2 + 5x + 6}{x^2 - 1} \div \frac{x^2 - 9}{x^2 - 2x - 3}$ . (9) [20]

6. A grocer buys 15 lbs. of figs and 28 lbs. of currants for £1. 1s. 8d; by selling the figs at a loss of 10 per cent., and the currants at a gain of 30 per cent., he clears 2s. 6d. on his outlay. How much per pound did he pay for each? [22]

7. (a) Calculate  $\tan A$  if  $\sin A = \frac{1}{3}$ . (6)  
 (b) Which is the greater  $\sin A$  or  $\cos A$  if  $A$  is less than  $45^\circ$ ? (2)  
 (c) Why can sine  $x$  never be greater than unity? (4)  
 (d) In  $\triangle ABC$   $\angle B = 90^\circ$ ,  $BC = 3''$ ,  $AB = 4''$ . Calculate  $AC$  and write down the values of  $\sin A$ ,  $\cos A$  and hence  $\frac{\sin A}{\cos A}$ . What is this last trigonometrical ratio called? (10)



- (e) A ladder 20 feet long is placed against a wall so that its top makes an angle of  $30^\circ$  with the wall. Calculate how far the foot of the ladder must be placed from the wall. [Given  $\cos 60^\circ = \frac{1}{2}$ ] (8)

- (f) A man wishes to find the width of a river. He stands at B immediately opposite an object A on the other side, he then walks 100 yards along the bank to C and finds  $\angle BCA$  to be  $40^\circ$ . Calculate the width of the river (to the nearest yard, given  $\tan 50^\circ = 1.1918$ ). (10) [40]

8. The following table gives the weights of men at different heights from 5 ft. 4 ins. to 6 ft. 2 ins.:-

Height in inches...	64	67	69	71	74
Weight in lbs.....	140	152	162	172	191

From these figures draw a graph and find from your graph the normal weights of men of heights 5' 8" and 6'.  
 [Scale: 1" of your paper to represent 2" in height, 1" = 10 lb.; let the origin represent 64" in height and 140 lb. in weight.] [18]

9. (a) If  $y = 3x + 7$  is the equation of a certain straight line, write down the equation of a straight line parallel to this line and passing through the origin. (4)  
 (b) (i) On the same axes draw the graphs of  $3y - x = 3$  and  $2x + 3y = 3$ . Use your graphs to solve the equations  $3y - x = 3$  and  $2x + 3y = 3$ . (16)  
 (ii) Join the point of intersection of these two graphs to the origin and find the equation of this line. (7) [27]

10. (a) In fig. I AOB and OC are straight lines. If  $\angle COB = 30^\circ$  then  $\angle AOC = \dots$  because if one straight line stands upon another then... (4)

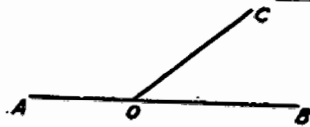


Fig. I.

- (b) In fig. II  $AC^2 = AB^2 + BC^2$ .  
 $\therefore \angle ABC = \dots$  (2)

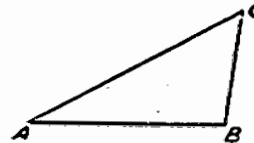


Fig. II.

- (c) In fig. III  $\angle ACD = \dots$  and  $\angle ABC + \angle ACB + \angle BAC = \dots$  (4)

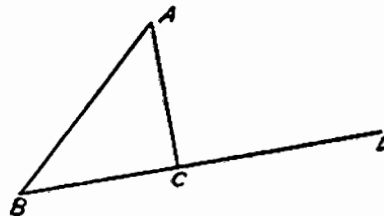


Fig. III.

- (d) In fig. IV AB is parallel to CD. Name two pairs of angles which are equal.

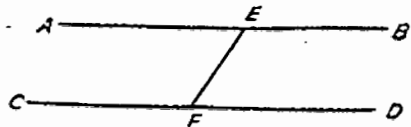


Fig. IV.

(4) [14]

11. AB is any chord of a circle, centre O. C is any point on the circumference of this circle. Prove  $\angle AOB = 2\angle ACB$ . (10)

A chord AB subtends an angle of  $100^\circ$  at the centre O. C and F are two points on the major arc AFB. AD is a tangent to the circle at A. Calculate the magnitudes of the angles ACB, AFB, OAB, BAD. (10) [20]

12. In a  $\triangle DEF$  we have  $DE = DF$ . Prove  $\angle DEF = \angle DFE$ . (10)

In  $\triangle ABC$ ,  $AB = AC$ ,  $\angle ABC = 70^\circ$ . D, E, F are the midpoints of the sides AB, AC, BC, respectively. Join DE and DF and calculate the magnitudes of angles BAC, ADE, DFC, FDE. (14) [24]

13. A boat leaves a lighthouse at the end of a harbour and sails N  $20^\circ$  E (i.e.,  $20^\circ$  to the E of N) for 1,000 yards, then N  $16^\circ$  W (i.e.,  $16^\circ$  to the W of N) for 550 yards, and finally due West for 400 yards.

By accurately drawing a figure to the scale of 1 cm. representing 100 yards, find the distance and bearing of the boat from the lighthouse. [17]

been adequately established.

The investigations of Burt (1, P 56) is representative of what has been done in England. He claims that his findings establish the following abilities:

- (1) General educational ability.
- (2) Arithmetical ability.
- (3) Manual ability.
- (4) A Linguistic or verbal factor.

He suggests that the linguistic factor may be composed of two parts:

- (i) An elementary verbal factor (reading and spelling) and (ii), a literary factor (composition and essay subjects).

Professor Reyburn and Mr. Taylor (8) interpreted the five factors found in a battery, composed of sub-tests of the ordinary intelligence test, in the following way:

- (1) Immediate memory.
- (2) Eliminative reasoning.
- (3) Positive reasoning or insight.
- (4) Verbal ability.
- (5) Ability to re-arrange material mentally.

No real general factor was found.

Dr H.W. Smith (10) followed this up and made a factorial analysis of 19 sub-tests selected primarily for standards III - VI. Six factors were found and designated as follows:

- (1) Immediate memory.
- (2) Positive reasoning.
- (3) A verbal factor.
- (4) Flexibility in accordance with rules. (Corresponding to the 5th factor found by Professor Reyburn and Mr Taylor).
- (5) Fluency.
- (6) Ability to profit by training. (Corresponding to Burt's General Educational Ability).

From the theoretical viewpoint the results of the work done on the subject can be regarded as supporting one of the following alternative hypotheses:

- (1) A General factor plus specific factors.
- (2) No general factor but only group factors.
- (3) One or more general factors, plus group factors.

The investigations up to the moment have indicated that (1) can safely be crossed off.

<sup>1</sup>( The number in brackets refer to the sequence in the bibliography.)

## CHAPTER II.

### DESCRIPTION OF THE DATA.

The data in this investigation consists of the Cape of Good Hope examination results in Std VI and Std VIII (Junior Certificate).

The idea was to find a large group of boys in J.C. all of which had been in the same class in Std VI two years earlier.

The procedure was to obtain the names of the pupils who had written the J.C. examination in 1944. This was most conveniently obtained from the Departmental examination results of that year and by kind permission of the Department.

The names which appeared in the 1944 results were then traced back to the Std VI examination results of the junior school. All the names of the pupils who had been together in Std VI and moved over in one group to the Secondary school, were then retained.

Two schools were chosen in which the standard of teaching was about equal. This information was kindly supplied by the inspectors of the circuit.

The following subjects were chosen - The number in brackets before each denoting its reference in the correlation table:

Std VI: (1) English Grammar. (2) Spelling. (3) Geography.  
(4) History. (10) Mechanical arithmetic and (11) Ordinary problem Arithmetic (written paper).

Junior Certificate: (6) English (total). (7) physics and chemistry.  
(8) Biology and (9) Mathematics.

To these were added (5), the Date of Birth.

The Std VI results were obtained from the Department of Public Education Class Schedule (form S12).

The way in which the Std VI final examination results are arrived at is as follows:

Examination questions are drawn up by the Department and a detailed memorandum furnished as a guide for marking the papers.

The teachers at the schools then mark the papers themselves with the aid of the memorandum. These results are then moderated by the inspector of the particular circuit in accordance with the standard memorandum supplied.

The two schools chosen happened to be in different circuits.

On the class schedule also appears the pupils average mark for the year in each subject. These marks are used when a decision has to be made in borderline cases.

The J.C. results are of course all strictly departmental, the marking

#.

the examination consisted of two parts.

In Geography the written paper counts 70 and 30 marks are given for themes in which the pupil does original work e.g. drawing and illustrating of a map to show the various mining industries in S. A.

In History, the written paper counts 50 and themes also 50.

These marks do not always appear separately on the class schedule and in both Geography and History the total mark - out of 100 - had to be taken.

\* For a discussion on the effect of this, see section on the reliability of the measures.

\* Copies of the original examination questions are given in appendix B.

THE RELIABILITY OF THE MEASURES.

The nature of the data used in this thesis is such that a true reliability cannot be calculated.

The measures used are examination results and the best that could be done was to compare the class examination results with the Departmental results.

If these two examinations - the class and the Departmental - could be regarded as exactly parallel forms of the same test then the correlation between the two would be also the reliability of the examination.

\* This, however, cannot be said of the data used and the correlations shown on table, is more in the nature of a validity of the examinations. It indicated to what extent one can rely on the class examination to give an estimate of the pupils standing in the subject as measured by the Departmental examination.

Another difficulty is that at the big schools a class has to be divided into sections under different teachers. For example sections (a) and (b) may have Mr X for English while sections (c) and (d) have Mr Y for the same subject.

\* The class examination results will suffer from differences in the standard of marking as well as the difficulty of the questions set by the two teachers.

A way out of the last difficulty would be to take the group under each teacher separately and then average the correlations of the separate groups. This, however, made the number of cases in the separate groups very small and consequently the probable error very large.

Finally the classification of a class into groups is not random; usually

B.

together. This fact excludes the possibility of using the technique of "equating the means" and rescaling of the marks of the separate groups in order to make them comparable.

The largest group available in which records were complete for the purpose of comparing the class with the Departmental marks, numbered only 43. This is due to the way in which the pupils were selected as explained in \* Chapter II.

\* Table I with due regard to each probable error must, therefore, be taken as to some extent indicating which of the subjects are best for objective scoring. The more objective a subject is the least will it suffer from all the difficulties enumerated above.

Only in the case of No. (3), Geography (Std VI) and No. (4), History (Std VI) were the whole class taught by the same teacher in each case.

Now leaving out correlations .89 and .51 i.e. those referring to Spelling and English (total) we have correlations with a range from .69 to .8 which comes to .11. The average of the probable errors is .05 approximately.

With these subjects, therefore, the variation appears to be mostly due to the probable error of the correlation.

Correlation of Departmental and class Results.	Departmental V Class results.	Probable Error.
1. English Grammar (Std VI)	.74	.05
2. Spelling "	.89	.02
3. Geography "	.67	.06
4. History "	.77	.04
6. English (total) (Std VIII)	.51	.08
7. Physics and Chem. "	.80	.04
8. Biology "	Data not available.	
9. Mathematics "	.80	.04
10. Mechanical Arith. (Std VI)	.69	.05
11. Problem Arith. "	.69	.05

N = 40.

Table I.

\* The objectivity of (2) spelling and the subjective nature of English (r = .51) is, however, obvious as can be seen when referring <sup>also</sup> to appendix B where examples of the respective exam papers are given.

The data of this investigation, however, are examination results in which the same paper was written by all the pupils and the marking done by reference to a detailed memorandum supplied by the Department.

It can be assumed that the true reliabilities of the measures will at least not fall below the figures given in the table.

Another problem which presented itself was whether the correlations would

A.

schools were pooled.

It was argued that if factors like differences in the standard of teaching, marking and the like did affect the correlations, then higher correlations could be obtained by taking pupils only from the same school. The correlations will of course differ when calculated with a heterogeneous set of pupils and the point to be decided was whether this difference could be ascribed as due mostly to the probable error or whether attenuation was also present.

Now it can be assumed that the standard of marking in the J.C. Departmental examination would of necessity be more uniform than the marking in the final Std VI examination. The first obvious advantage of the J.C. examination results is that they are marked by paid examiners in the department whereas the Std VI papers are done by the teachers of the schools themselves with the aid of a memorandum supplied by the department.

In the case of subjective subjects then, the correlations involving the Std VI results would be the first to suffer.

With this in view certain variables were chosen which appeared to be most liable to error. These variables were subjects all chosen from Std VI with one exception, namely (7) physics and chemistry.

Tables II and III show a comparison of two sets of correlations. In table II the correlations were calculated using pupils from only one school. In table III the correlations were those obtained from the original correlation table where the pupils from two schools are mixed up.

Intercorrelations calculated from the results of pupils all in the same school. N = 70.

	(1) English Grammar.	(3) Geogra- phy.	(4) Hist- ory.	(7) Physics and Chem.
1.			.52	
3.			.56	.35
7.	.32			
9.		.45		
10	.34	.39	.37	.64
11	.32	.24	.29	.60
Col. Total	.98	1.08	1.74	1.59
Col. Aver.	.33	.36	.44	.53
Average correlation:				.415

Intercorrelations obtained where the pupils from two schools are mixed up. N = 120.

	(1) English Grammar.	(3) Geography.	(4) His- tory	(7) Physics and Chem.
1.			.51	
3.			.63	.37
7.	.38			
9.		.31		
10	.43	.39	.31	.61
11	.35	.29	.30	.52
Col. total	1.16	.99	1.75	1.50
Col. Aver.	.39	.33	.44	.50
Average correlation:				.415

Table III

5.

The average correlation, shown at the bottom of each table, comes to the same in each case. It was decided, therefore that the fluctuation in the correlations when going from table II to table III could be explained by the probable error and that the results from the two separate schools could be pooled with confidence when working out the correlations for the factorial analysis.

The above tables also tend to the conclusion that the system of marking at the Std VI departmental examination produces very uniform results.

\*\*\*\*\*

RESULTS.

Having thus obtained the scores of each pupil in the eleven subjects as described in the previous chapter, intercorrelations of these subjects were worked out using the product - moment formula. These correlations are shown on Table IV.

Correlation Matrix.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1. English Grammar Std VI.	(58)	41	39	51	18	45	38	31	34	43	35
2. English Spelling Std VI.	41	(45)	21	33	32	35	30	25	39	36	19
3. Geography Std VI.	39	21	(69)	63	11	22	37	12	31	39	29
4. History Std VI.	51	33	63	(68)	08	34	39	31	29	30	30
5. Date of Birth.	18	32	11	08	(37)	31	21	01	35	26	34
6. English (total) Std VIII.	45	35	22	34	31	(70)	55	61	51	43	49
7. Physics & Chem Std VIII.	38	30	37	39	21	55	(82)	68	71	61	52
8. Biology Std VIII.	31	25	12	31	01	61	68	(74)	41	43	53
9. Mathematics Std VIII.	34	39	31	29	35	51	71	41	(81)	69	47
10. Mental Arith. Std VI.	43	36	39	30	26	43	61	43	69	(79)	57
11. Arithmetic Std VI.	35	19	29	30	34	48	54	53	47	57	(65)

Table IV.

As a whole the correlations are definitely significant and of medium size. The average probable error comes to  $\pm .054$ .

All the correlations are positive with the exception of (8) with (5) which is, however, not significant when compared with its probable error ( $\pm .082$ ).

(5), The Date of Birth tends to correlate positively with all the other subjects. This is in agreement with the well known fact that the younger pupils tend to be the brighter. It also indicates the amount of selection that has taken place.

It will be noted that the highest correlation is .71, between the subject Physics and Chemistry and Mathematics. Next comes .69, between Mathematics and Mechanical Arithmetic. The combined subject Physics and Chemistry correlate .68 with Biology.

A curious result is that Mechanical Arithmetic (Std VI) and Mathematics (Std VIII) correlate higher than Mechanical Arithmetic and ordinary problem Arithmetic, both Std VI subjects, which only comes to .57. At a first glance

of two years between the two examinations *Mechanical Arithmetic and Mathematics*

Further inspection of the correlations shows that variables (3) and (4), Geography Std VI, and History Std VI, <sup>respectively</sup> correlate .63 with each other which stands out when compared with the correlations of these two with the rest of the subjects. Going down the two columns (3) and (4) the only other outstanding correlation is .51, that between History and English Grammar both Std VI subjects.

This tendency for the subjects to fall into separate clusters will appear again when the results of the factor analysis is discussed later on.

This factor analysis was carried out on the correlations in Table IV using the Centroid Method.

The resulting <sup>Centroid</sup> correlation Matrix<sup>1</sup> appears in Table V.

		I	II	III	IV
1.	English Grammar (Std VI)	.623	-.322	.112	-.151
2.	Spelling "	513	-.167	-.349	-.087
3.	Geography "	537	-.476	.232	.262
4.	History "	599	-.533	.232	-.019
5.	Date of Birth	363	.094	-.362	-.039
6.	English (total) Std VIII	714	.171	-.047	-.330
7.	Physics and Chem. "	798	.245	.220	.151
8.	Biology "	631	.288	.344	-.248
9.	Mathematics "	760	.261	-.185	.320
10.	Mechanical Arith. Std VI	757	.161	-.108	.311
11.	Problem Arith. "	677	.268	.129	-.141

Table V.

<sup>1</sup>See J.C. Flanagan "Factor Analysis in the study of Personality" (Stanford University Press), 1935 p32.

Three factors appeared to be enough to make the median of the residual correlations drop below the average probable error. It was, however, thought advisable to extract another factor and decide later on whether a meaning could be attached to it, or discarded as due entirely to error.

Leaving out factor IV for the moment, and using only factors I, II and III the results shown in Table V can be represented graphically i.e. on the surface of a sphere.

Figure (1) shows this graphical representation. Inspection of this diagram will indicate which of the subjects tend to cluster when only the first three factors are involved.

It must be pointed out that this diagram gives only a rough idea of how the school subjects tend to group themselves. Before projecting the points on the surface of a sphere, as described in appendix A, the points are located in a three dimensional space and at various distances from the origin,

then tend to distort the relative positions of points which are situated near the centre.

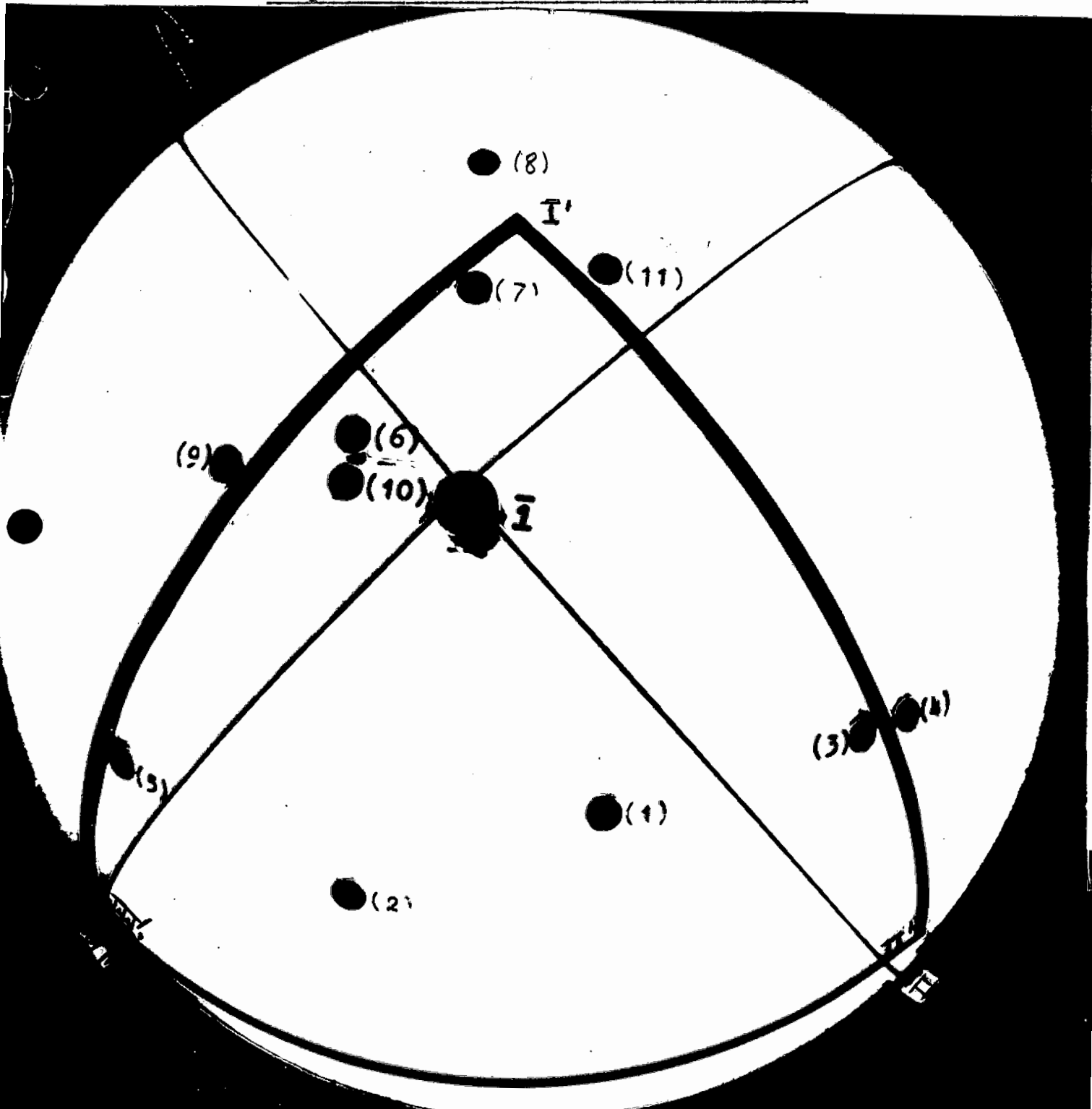
It does show however, that the subjects (7) Physics and Chemistry, (8) Biology and (11) problem Arithmetic tend to go together. (Apex of the Triangle) At the same time (3) Geography, and (4) History, appear to have much in common.

ROTATION OF THE AXES.

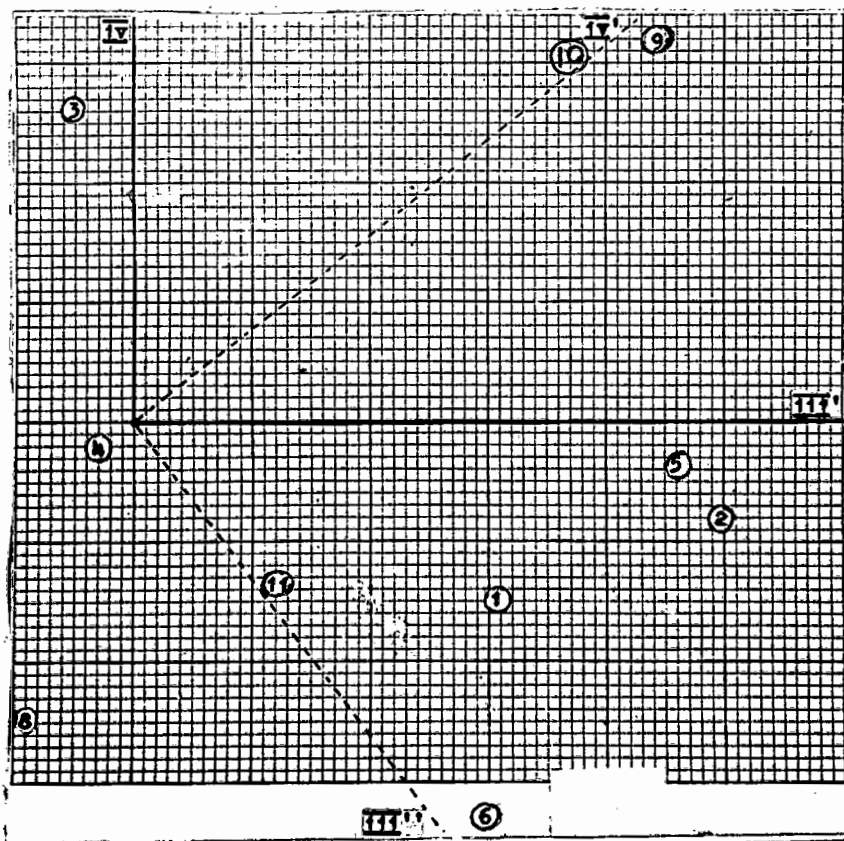
The rotation of the axes was carried out by hypothesis. It is essentially the same as the method followed by professor Reyburn and Mr Taylor in their factorial studies.

The axes were then rotated in accordance with the following assumptions (also given in the introductory chapter):

Graphical Rotation of Axes I II and III.



Graphical Rotation of Axes III' and IV.



Note: The centroid axis III, has now been rotated twice.  
Fig. (ii).

		I'	II'	III''	IV'
1.	English Grammar (Std VI)	404	499	307	149
2.	Spelling "	280	297	374	338
3.	Geography "	390	644	-239	119
4.	History "	425	717	035	014
5.	Date of Birth	232	001	317	344
6.	English (totalscore) " VIII	671	070	440	029
7.	Physics and Chem. "	858	050	-074	151
8.	Biology "	767	-036	135	-231
9.	Mathematics "	696	-011	019	545
10	Mechanical Arith Std VI	685	089	-022	478
11	Problem Arith. "	729	-018	184	007

Table VI. Rotated Matrix.

- (a) There is a strong general factor entering into all the subjects.
- (b) All the factors have a positive influence. i.e. There must be no significant negative values in the rotated loadings.
- (c) All the factors are independent. Mathematically this means that all the axes must remain orthogonal when rotated.

Table VI shows that the first centroid factor - factor I - to be a fairly general factor. With this in mind it was decided to change its position as little as possible. This was done as shown on figure (i).

The apex of the triangle was placed roughly in the centre of the points (7) Physics and Chemistry, (8) Biology and (11) problem Arithmetic.

This was the crucial point and really fixed the position of the other two axes in advance.

if they are to have positive loadings on the rotated axes.

Those points, when plotted on the sphere, form a pattern of which the outline is roughly triangular. Having fixed the position of the first axis in accordance with the hypothesis that variables (7) (8) and (11) have this factor in common, the position of the second and third axes were predetermined within narrow limits by the stipulation (b) above (previous page).

\* The transformation matrix was then derived as explained in appendix A, and the new loadings on factors I' II' and III' calculated.

It appeared then that factors I' and II' allowed of psychological interpretation but that III' was somewhat obscure. Factor III' was thus rotated a second time with IV as shown in figure (ii).

The axis IV' was passed through the centroid of (9) and (10) Mathematics and Mechanical Arithmetic respectively. This, in other words is a negative rotation of the axes through about 50°. With this rotation axis III'' passed close to (6) which is English (total) Std VIII. At the same time the negative loads inevitable on (3) and (8) was divided about equally between the two.

The Sine of this angle, when determined correct to 3 figures, comes to 0.789 and its Cosine + 0.615. Using the transformation matrix

$$\begin{bmatrix} .615 & .789 \\ -.789 & .615 \end{bmatrix}$$

the rotated loadings for factors III'' and IV' were calculated algebraically.

The rotated matrix for the four factors appears on table VI.

#### FINAL ROTATION.

The first attempt at rotation produced a factor pattern which as a whole was not inconsistent. Referring back to table VI, however, it will be seen that there are two fairly large negative loads.

Variable (8) has a load of -.23 on factor IV', and Geography, variable (3), carries a load of -.239 on factor III''.

Now these negative loads may be entirely due to error as the median residual, after extraction of factor III already fell below the average probable error.

But in order to make a rigorous test of the hypothesis, namely, that all factors should have a positive influence, the centroid axes were rotated a second time with a view to minimise these two negative loadings and at the same time preserve the factor pattern of table VI. This final rotation

## FINAL ROTATION OF THE CENTROID AXES I, II and III.

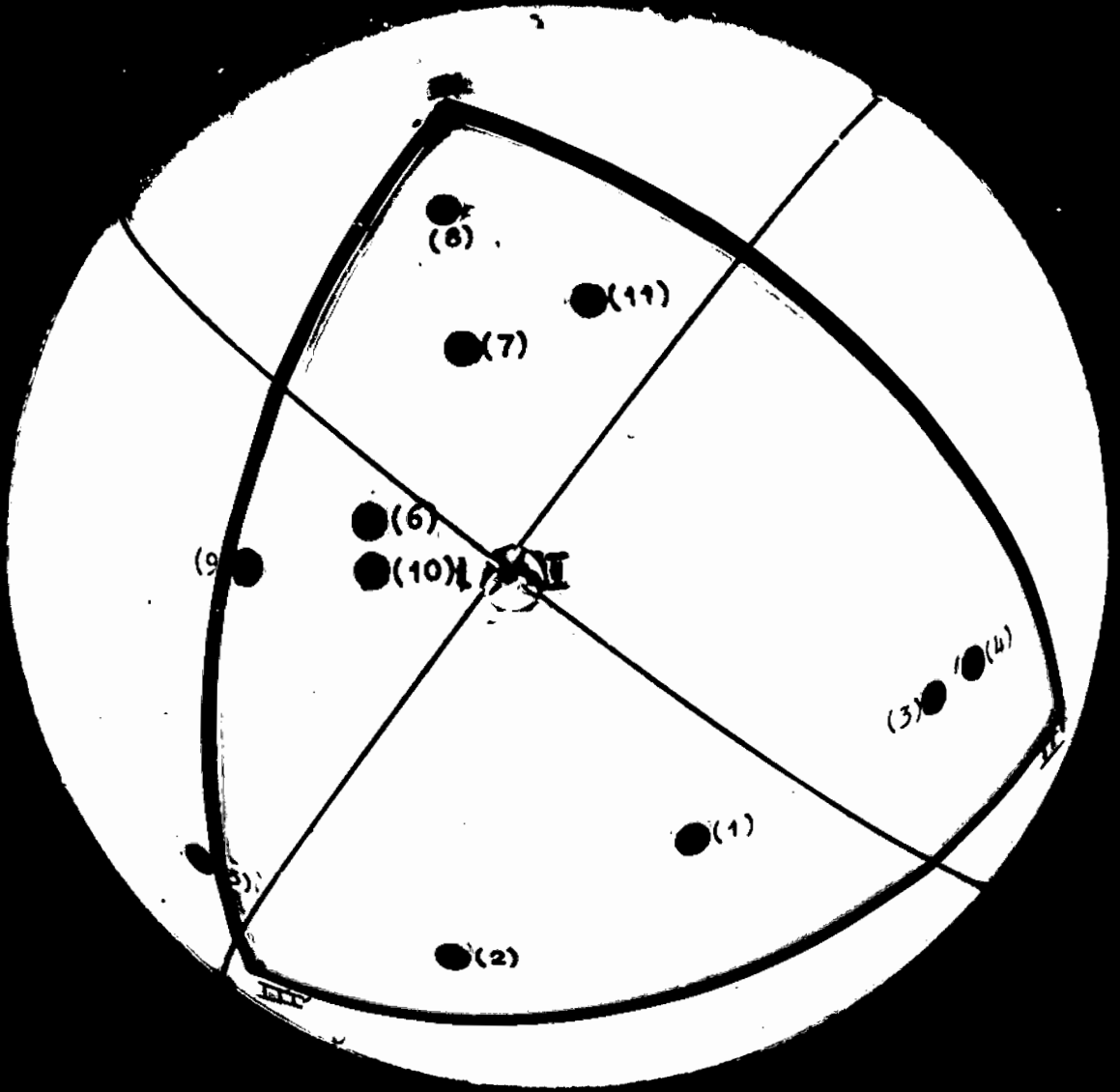


Fig. (iii).

Final Rotated Matrix: Factor loads.		I'	II'	III'	IV'
1.	English Grammar (Std VI).	202	477	419	291
2.	Spelling "	094	214	437	418
3.	Geography "	226	700	501	296
4.	History "	278	761	147	156
5.	Date of Birth.	129	070	340	372
6.	English (total) J.C.	564	122	540	157
7.	Physics and Chem. J.C.	790	194	060	323
8.	Biology "	757	137	250	084
9.	Mathematics "	578	013	110	661
10.	Mental Arithmetic (Std VI)	555	124	082	611
11.	Problem Arith. "	677	091	288	140

Table VII.

7.

FINAL ROTATION OF AXIS III' WITH IV.

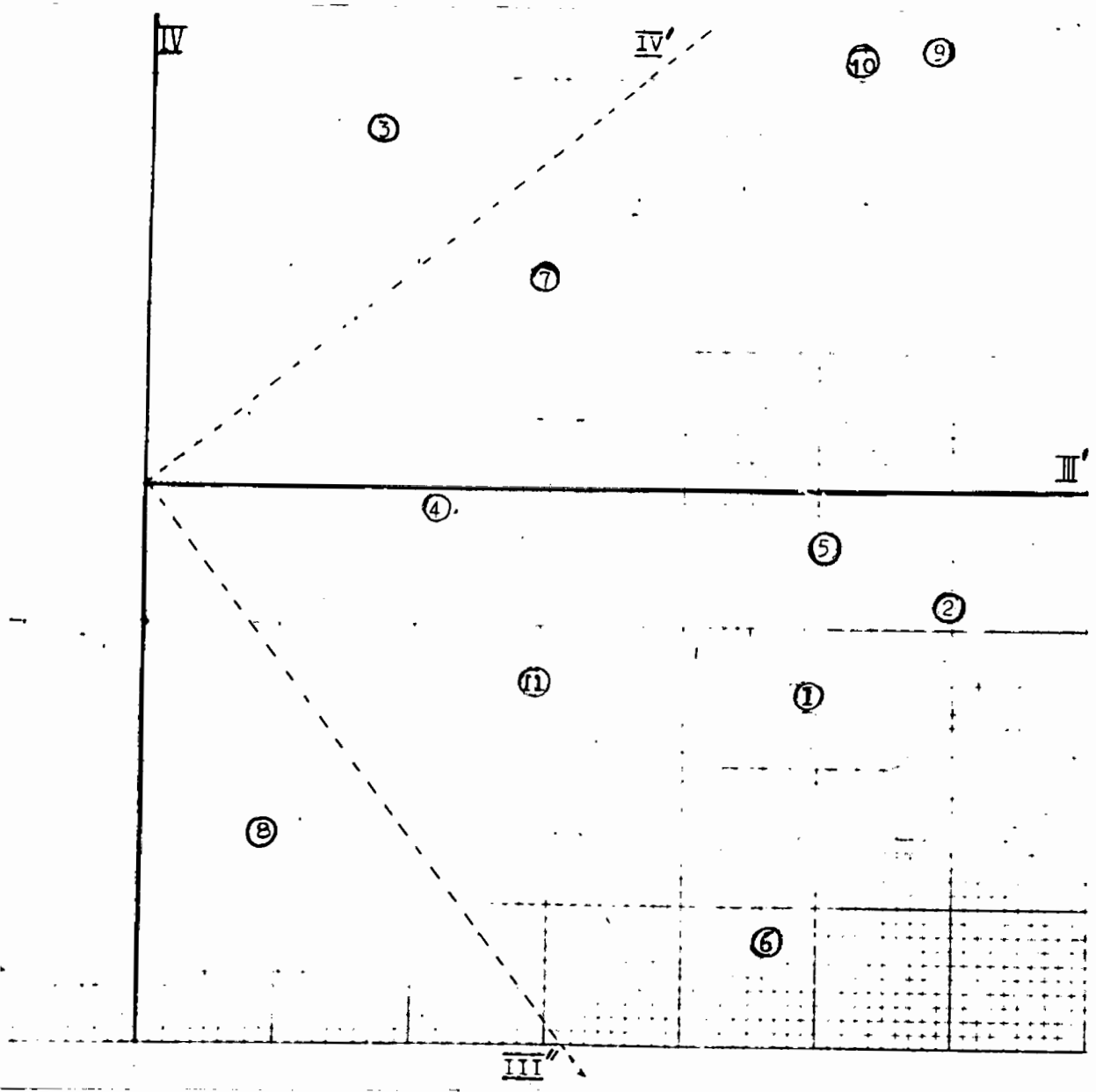


Fig. (iv).

Final Rotated Matrix: Variance.				
	I' (%)	II' (%)	III' (%)	IV' (%)
1.	4.1	22.7	17.5	8.5
2.	0.9	4.6	19.1	17.5
3.	5.1	49.0	1.0	8.8
4.	7.7	57.9	2.2	2.4
5.	1.7	0.5	11.6	13.8
6.	31.8	1.5	29.2	2.5
7.	62.4	3.8	0.4	10.4
8.	57.3	1.9	6.2	0.7
9.	33.4	0.0	1.2	43.7
10.	30.8	1.5	0.7	37.3
11.	45.8	0.8	8.3	2.0

Table VIII.

Comparing figure (iii) with figure (i), it can be seen that this second rotation really amounts to making factor I' less general. This makes the influence of factor I' less and increases the significance of the other three factors.

~~8.~~

investigation it will be more illuminating to examine the factors found in terms of the percentage of the variance due to each. This appears in table VIII.

The factor pattern on table VIII appears, to some extent, to support the hypothesis of one or more general factors plus group factors. (This is given as the third alternative in chapter I).

It must, however, be pointed out that the contribution of the first factor (a fairly general factor) to variables (1) - (5) is slight when compared to its significance in variables (6) - (11). Variable (5), date of birth, is however, not relevant to the argument here.

The ~~following~~ interpretation of the data <sup>in the following chapter</sup> is to a large extent the outcome of discussions with the following people who were kind enough to render every assistance: The Supervisor of the thesis, members of the staff of the University, officials of the Cape Department of Education, the inspectors of the schools chosen, and the principals of these schools.

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THE FACTORS FOUND.

FACTOR I': INSIGHT. This factor is best represented by the J.C. subject, Physics and Chemistry, followed by Biology, Arithmetic, Mathematics, English (total score) and finally Mechanical Arithmetic. In this final rotation of the axes this factor appears to move away from the quantitative subjects. English (total), for instance, has more of this factor than Mental Arithmetic.

This factor is very much a border line case although for the present it can be regarded as a general factor. Its lowest contribution is found in variable (2), spelling, the percentage being 0.9.

The next question is whether this factor represents a general <sup>innate</sup> ability or whether it can be produced by circumstances in the class room.

R.R. Wolf, Jr. (12, p47), for instance, suggests that the failure of his tests to differentiate between the verbal and quantitative abilities of students may be due to the strong influence of ~~this~~ <sup>a</sup> "central factor". He suggests also that this central factor may in part be due to the fact that pupils try to improve their scoring in those subjects in which they are weak. This of itself would produce a general factor making for equalized achievement.

He appears to be correct in ascribing the failure of his tests to differentiate the verbal from the quantitative to the presence of ~~this~~ <sup>a</sup> central factor. Fig. (iii) indicates that both English (total) and Mathematics have factor I as a common factor and to an amount of over 30 percent of the variance.

The fact that this factor is best represented by the sciences is the next important point.

One may define a Science as a body of knowledge arrived at in the following way. First comes the collection of data, next the organization of these data and finally its reduction to a few fundamental laws revealed in all the data. If this definition is accepted then factor I may be called ["Insight"].

It conforms somewhat to Thorndike's definition of Abstract Intelligence quoted by R.R. Wolf (op.cit. p5) as the ability to understand and manage ideas and symbols such as words, numbers, chemical or physical formulae, legal decisions, scientific laws and principles and the like.

It also appears to fit into Spearman's definition of General Intelligence as the ability to see relations.

In the analysis of intelligence carried out by professor Darburn and

regarded as reasoning factors. Factor II is however eliminative reasoning and III positive reasoning or "Insight".

In the present analysis, however, the variables were examination results and not tests with a choice of alternatives. This separation into two factors, both reasoning in character is therefore hardly possible., eliminative ability is here excluded.

It is suggested then that factor I' of this investigation may well be a combination of factors II and III found in the article quoted.

L.L. Thurstone and T.G. Thurstone (11) in the introduction considers that an inductive or reasoning factor has shown up repeatedly in their analysis.

At the end after analysing two batteries of tests the inductive or reasoning factor is shown as indicated by tests in which the underlying idea could be discovered. On page 36 they state that this factor has the highest correlation with what they call "a second-order general factor .... which may perhaps be interpreted as Spearman's General Factor or as a maturation [factor".

In summing up this factor one may speculate as to whether it can be reconciled with conceptions derived from the Rorschach test. Here the indications are that highly intelligent subjects display the ability to see the the ink blot at a whole.

These people, as it were, can create a unity from material which to other people appear as chaos.

This consideration would then tend to reconcile one to the fact that both the "Arts" and the "Sciences" seem to be influenced by a more fundamental common factor.

Judd (69 p343), for instance, defines a scientific law as essentially a product of the creative power of the human intellect. For him it is a mental shorthand and he considers that a scientific law cannot exist outside of the mind.

Now the total score in English in Junior Certificate is composed mostly of literature and essay writing which can be called creative.

If, therefore, we want to assume that this tendency to embrace literature, as well as science is an innate quality of the first factor then the nature of this factor <sup>can</sup> perhaps also be described as synthetic. In the Rorschach Test terminology this should not be taken as indicating the "built up whole Response". It corresponds rather to the tendency which is scored

~~5.~~

It must be pointed out, however, that, statistically, part of this factor may be due to the way in which the variables were selected. The subjects (6) English (total) (7) Physics and Chemistry, (8) Biology and (9) Mathematics are all Std VIII subjects and one would expect, therefore, that the correlations between these subjects would be higher than between the latter and the Std VI subjects; the variables intercorrelated here are separated by an interval of two years.

On the other hand inspection of the correlation table shows that even with an interval of two years elapsing between the two examinations it is still possible to get a correlation as high as .69 between (10) Mechanical Arithmetic (Std VI), and (9) Mathematics Std VIII. This suggests that the effect of the two years difference is not very substantial.

It must be conceded then that it is possible that both innate ability as well as external conditions, peculiar to the situation, contribute to the appearance of this first factor.

As to whether it is a general factor or not, will depend on whether we are referring to practical life or only to the eleven variables in the correlation table.

In the school situation, for instance, and whether innate or not, it operates as a general factor which makes it difficult to distinguish the literary from the scientific and mathematical ability.

Factor II'; Memory: A first indication of this factor appears in the correlation table (table IV). In the first four variables the only outstanding correlation is between History and Geography which comes to  $.63 \pm .037$ . This suggests a factor or factors common to both History and Geography.

In the final rotation of the axes the position of axis II' was already fixed by the restrictions as given in chapter III. These restrictions imposed on the rotation of the axes then tended to place II' near to (3) and (4), Geography and History respectively.

In terms of variance this factor is best represented by History in Std VI closely followed by Geography and then to some extent by Spelling. Of the other variables the highest is Physics and Chemistry which however comes to under 4%.

As to whether it is a general factor or not, one may say that it is of about the same order of generality as the Immediate Memory factor found

A.

A student suggested that this factor confines itself to subjects that can be "swotted".

L.L. Thurstone and T.G. Thurstone (op. cit.) considers their memory factor M to be the most independent primary factor with the smallest number of significant correlations with their separate tests. On page 5 (op. cit.) they define M as the ability to memorize anything quickly.

By referring to appendix B it will be seen that especially History in Std VI is a subject which must be memorized. The fact that in History 50% of the marks are rewarded for themes and in Geography 30%, does not seem to to introduce a complication.

This factor may then be assumed to be also this ~~general~~ <sup>of Thurstone.</sup> memory factor. It is possible that its correlation with "Immediate Memory" will be quite high, assuming Thurston's definition, "the Ability to memorize anything quickly", to be correct.

Factor III': Language. In factor III', English (total) is associated again with what one would expect. The highest factor load is that of (6), English (total), followed by Spelling and English Grammar. The date of birth appears also to be just significant. (11) Problem Arithmetic, and (8) Biology has perhaps also some meaning here.

This can be called a language factor; a factor which already appears to be firmly established in the literature.

In the article by professor Reyburn and Mr. Taylor (op. cit.) a verbal factor appeared and contributed 11% of the variance in the absurdities test. In the present analysis the variance due to factor III' <sup>is</sup> 8.3% for problem Arithmetic. This is explained if one considers the fact that in Problem Arithmetic most of the marks are awarded for a verbal setting out of the sum in successive logical steps.

Arithmetic in Std VI may therefore be regarded as to some extent a reasoning test in terms of words.

Factor IV': This is put forth provisionally.

In the factor analysis the median residual of the correlations fell below the average probable error after factor III was extracted. On reflection of the residuals, however, the no of negative signs remaining could not be explained by chance alone. Using the formula  $\sigma = \sqrt{kpq}$  where  $p=q=0.5$ ,

5.

average we have:

$$\begin{aligned} \text{Range} &= \text{Average} \pm 3\sigma = \frac{121}{2} \pm 3 \times 5.5 \\ &= 60 \pm 16.5 \\ &= 43.5 - 76.5 \text{ (from 43.5 to 76.5)} \end{aligned}$$

In the analysis the number of minus signs remaining was actually 28. This suggested the presence of a fourth factor probably mixed up with some error.

The two outstanding loads here are on (9) Mathematics in J.C. and (10) Mental Arithmetic in Std VI. Spelling is probably also significant.

One is tempted to call this a numerical factor; meaning the aptitude involved in Mechanical Arithmetic.

Dr. H.W. Smith (op. cit.), however, isolated a factor which can be called mental manipulation according to set rules (the fourth factor given in his analysis).

This name appears to be more comprehensive and apparently fits the observed facts of the present analysis quite well. This factor has now shown up, with slight modifications, in the three separate analyses mentioned and its existence can be assumed to be fairly well established. Further investigation is needed to determine its exact nature.

The fact that (5) date of birth, has a loading of .37 can be explained as due to the amount of selection which has operated up to the secondary school stage. The meaning of this correlation between the date of birth and the fourth factor is that pupils born more recently have more of this ability. This is in accordance with the well-known fact that, in any subject, the younger pupils tend to score highest.

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The application to Education.

Prediction of Scientific ability in Std VI. The practical implications of the investigation can now be glanced at briefly. First one may examine the factorial composition of science in J.C..

The combined subject **Physics and Chemistry**, as taught and tested in the Junior Certificate examination depends on "Insight", to the extent of 62% of the total variance.

The next most important factor in **Physics and Chemistry** is number IV' which was called the ability to follow rules. It must be noted, however, that it is responsible for only 10% of the variance. Both factors II' and III' appear to be negligible. This can be interpreted by saying that everyone appears to have enough of the little memorising and language ability necessary for success in **Physics and Chemistry**.

It must also be noted that in this subject the common factors account for just over 75% of the variance. Only 25% is unique, i.e. due to factors which are unknown at present.

Turning now to the major problem as outlined in the introduction one may determine how these factors, making for success in **Physics and Chemistry**, are indicated in Std VI.

One of these factors "Insight", is best represented by problem Arithmetic in Std VI. The table shows that 46% of the variance in this subject is due to this factor. Mechanical Arithmetic, again, is the best indicator of the ability to apply a rule (factor IV').

A combination, therefore, of the two Std VI subjects, (11) problem Arithmetic, and (10) Mechanical Arithmetic, promises to have a high multiple correlation with **Physics and Chemistry** in Junior Certificate.

Mathematical ability. The tables indicate that the chief factor here is IV' (The ability to apply a rule). The factor "Insight" is not far behind and accounts for 33% of the variance. Together these two factors account for just over 75% of the individual differences in Mathematics. Again a little less than 25% is due to unknown factors.

In Std VI, therefore, one would expect a weighted combination of (10) Mechanical Arithmetic, and (11) problem arithmetic, to have high predictive value for success in Junior Certificate Mathematics. It is clear that in this multiple correlation more weight will have to be placed on Mechanical Arithmetic.

at the Std VI level children can with confidence be classified into the following two sections:

- (a) Those with intellectual leanings; the academic type, ~~and~~
- (b) Those who will do best at work involving only memory and work of a reproductive kind. It is very probable that these children will prove to be the manual type. These are the pupils who would cope quite well with, for instance, Geography and History in Std VI but would show little aptitude for Arithmetic.

The essential difference between these two groups would be that of amount of "G" possessed by the pupils. The usual intelligence test might also serve to effect this separation.

When it comes to special abilities, however, this investigation appears to confirm previous researches of which Wolfe (op. Cit.) is representative.

Due to the influence of a central factor - probably partly innate and partly due to the external situation - the separation of especially mathematical and literary ability becomes difficult. It will be noted on table VII, that both (6) English (total) and (9) Mathematics have a high loading on the first factor.

This is in line with the results of Kelly, Rogers and King which are quoted by Earle (3).

These investigators drew up tests selected from the usual intelligence test which, however, failed to differentiate between the language group and the mathematical group of subjects.

The reason for this can be seen by noting the relative importance of the four factors involved. It must be remembered that in the factorial analysis of the correlation table only three factors were sufficient to reduce the median residual correlations below the average probable error of the original correlations.

The fourth factor, as it were, appeared to be still in the process of emerging. At this stage the average probable error of .054 is too large to allow for an exact determination of the fourth factor. The average age of the pupils at the time of writing the Std Vi examination comes to 13 years 8 mths

Now it is well known that abilities become more differentiated as age and training increases. (See for instance Earle Op. Cit.). It would be of value to know at what stage the factors become definite enough to allow a safe differential prediction to be made. This investigation really repre

but one is justified to conclude<sup>8.</sup> that Std VI appears to be a little bit early for making decisions involving the fourth factor.

This factor contributes 44% of the variance observed in the scores of the pupils in Std VIII Mathematics, while "Insight" is responsible for 33%. This factor, - the ability to follow a rule - appears then to be of great importance in the differential prediction of success in Mathematics. Unfortunately, however, the fourth factor is only vaguely indicated at the Std VI stage and its exact contribution is as yet unreliable.

The distinction between the subject physics and chemistry and English appears to be more definite. Here "Insight" is twice as important in physics and chemistry as compared to its contribution in English.

Finally however, it must be remembered that Science in the Junior Certificate is something different from what it is at university and in practical life. Here factors such as experimental technique come in, and the treatment always tends to become more and more mathematical. One would be inclined to discourage a pupil from taking up physics, for instance, as a career, if he is lacking in the fourth factor; mental manipulation according to set rules.

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Rotation of the Axes.

Mr. Taylor, under whose supervision this investigation was made suggested a method by which the centroid axes can be rotated graphically.

It consists, essentially, in projecting the points on the surface of a sphere.

The first three axes only were used for the time being and their origin taken as coinciding with the centre of a sphere (in this case an electric light globe).

Theoretically one can then imagine the top half of the sphere as containing the eleven variables and represented by points plotted with reference to axes I, II and III.

The points will all be in the top half of the sphere if we take the first centroid axis as being the "polar axis"; the first centroid factor loadings ~~are~~<sup>being</sup> always positive.

These eleven points can now be projected on to the surface of the sphere by a mathematical technique known as "normalizing".

In this, the factor loadings are converted to direction cosines and can then be plotted on the surface of the sphere by means of circular scales marked off in cosines.

Figures (i) and (iii) show the sphere when viewed vertically from above. Mathematical Technique. The three points where axes I II and III pass through the sphere can be seen to form an equilateral triangle on a spherical surface. The rotation of the axes, three at a time, can then be carried out graphically, by moving this triangle so as to enclose the area required.

In the diagram the quadrants formed by the centroid axes are represented by the thin lines. The heavy lines show the quadrant formed by the rotated axes. With this technique it is obvious that the <sup>three</sup> rotated axes will always be mutually at right angles.

The next step is to calculate the new factor loadings on the rotated axes. This involves the writing of a transformation matrix in three dimensions which will rotate the centroid axes to their new positions as shown in the diagram. Figure (iii).

In order to obtain the first column of this transformation matrix, the new position of axis I' must be determined. This is obtained with reference to the original centroid axes and is measured in terms of direction co-

and calculating the third value knowing that the squares of the three direction cosines sum to unity.

The accompanying table, which is due to Mr. Taylor, can then be used to obtain an arbitrary matrix with the first column containing the values measured as described above.

In order to arrive at the final transformation matrix which will rotate the axes to correspond to the graphical positions, the arbitrary matrix is post multiplied by a matrix of the form

$$\begin{array}{ccc} 1 & 0 & 0 \\ 0 & p_1 & q_1 \\ 0 & p_2 & q_2 \end{array}$$

If  $B_1$  and  $B_2$  say are the values required in the second column of the final transformation matrix then  $p_1$  and  $p_2$  will be chosen so that:

$$b_1 p_1 + c_1 p_2 = B_1 \quad - (1)$$

$$\text{and } b_2 p_1 + c_2 p_2 = B_2 \quad - (2)$$

where  $b$  and  $c$  refer to the entries in the second and third columns of the arbitrary matrix found from the tables.

Now in the arbitrary matrix derived from the tables  $C_1 = 0$  also  $p_2 = q_1$  and  $p_1 = q_2$ , which enables us to obtain  $p_1$  and  $p_2$  as well as  $q_1$  and  $q_2$  from equations (1) and (2).

This procedure of obtaining the final transformation matrix can then be represented by the following matrix equation:

$$\begin{bmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 \\ 0 & p_1 & q_1 \\ 0 & p_2 & q_2 \end{bmatrix} = \begin{bmatrix} A_1 & B_1 & C_1 \\ A_2 & B_2 & C_2 \\ A_3 & B_3 & C_3 \end{bmatrix} = \frac{\quad}{\quad}$$

Where the capital letters represent the cell entries of the final transformation matrix.

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ORTHOGONAL TRANSFORMATIONS

The accompanying table enables one to write an orthogonal transformation in any number of dimensions from 2 to 15 when one column is known.

The general procedure is to put the elements in the first column of the symbolic transformation equal to the given direction cosines, to solve certain equations, detailed below, which yield numerical values for all the terms appearing in the remaining columns, and to substitute these values in the symbolic transformation. In what follows some of the equations are marked with an asterisk; these serve to check the computations.

2 For 2 dimensions take the first 2 rows and columns and put  $c=1$ .

$$a^2+b^2=1^*$$

3 For 3 dimensions take the first 3 rows and columns and put  $e=1$ .

$$b=\sqrt{1-a^2}; \quad c=bc/b; \quad d=bd/b; \quad c^2+d^2=1^*$$

4 For 4 dimensions take the last 4 rows and columns and put  $p=1$ .

$$w^2+x^2+y^2+z^2 = 1^*$$

5 For 5 dimensions take the last 5 rows and columns.

$$q=\sqrt{1-p^2}; \quad w=qw/q; \quad x=qx/q; \quad y=qy/q; \quad z=qz/q; \quad w^2+x^2+y^2+z^2 = 1^*$$

6 For 6 dimensions take the first 6 rows and columns and put  $j=1$ .

$$b=\sqrt{1-a^2}; \quad c=bc/b; \quad d=\sqrt{1-c^2}; \quad e=bde/bd; \quad f=ddf/bd; \quad g=bdg/bd; \\ h=bdh/bd; \quad e^2+f^2+g^2+h^2 = 1^*$$

7 For 7 dimensions take the last 7 rows and columns and put  $j=1$ .

$$s=\sqrt{1-(p^2+q^2+r^2)}; \quad w=sw/s; \quad x=sx/s; \quad y=sy/s; \quad z=sz/s; \\ w^2+x^2+y^2+z^2 = 1^*$$

8 For 8 dimensions take the last 8 rows and columns.

$$k=\sqrt{1-j^2}; \quad p=kp/k; \quad q=kq/k; \quad r=kr/k; \quad s=\sqrt{1-(p^2+q^2+r^2)}; \\ w=ksw/ks; \quad x=ksx/ks; \quad y=ksy/ks; \quad z=ksz/ks; \quad w^2+x^2+y^2+z^2 = 1^*$$

9 For 9 dimensions take the first 9 rows and columns and put  $p=1$ .

$$b=\sqrt{1-a^2}; \quad c=bc/b; \quad d=\sqrt{1-c^2}; \quad e=bde/bd; \quad f=ddf/bd; \quad g=bdg/bd; \\ h=\sqrt{1-(e^2+f^2+g^2)}; \quad j=bhj/bdh; \quad k=bhk/bdh; \quad m=bhm/bdh; \quad n=bhn/bdh; \\ j^2+k^2+m^2+n^2 = 1^*$$

10 For 10 dimensions take the last 10 rows and columns and put  $e=1$ .

$$n=\sqrt{1-(j^2+k^2+m^2)}; \quad p=np/n; \quad q=nq/n; \quad r=nr/n; \quad s=\sqrt{1-(p^2+q^2+r^2)}; \\ w=nsw/ns; \quad x=nsx/ns; \quad y=nsy/ns; \quad z=nsz/ns; \quad w^2+x^2+y^2+z^2 = 1^*$$

2.

11 For 11 dimensions take the last 11 rows and columns.

$$f = \sqrt{1-e^2}; \quad j = fj/f; \quad k = fk/f; \quad m = fm/f; \quad n = \sqrt{1-(j^2+k^2+m^2)};$$

$$p = fnp/fn; \quad q = fnq/fn; \quad r = fnr/fn; \quad s = \sqrt{1-(p^2+q^2+r^2)};$$

$$w = fns w/fns; \quad x = fns x/fns; \quad y = fns y/fns; \quad z = fns z/fns; \quad w^2+x^2+y^2+z^2 = 1 *$$

12 For 12 dimensions take the first 12 rows and columns and put  $w=1$ .

$$b = \sqrt{1-a^2}; \quad c = bc/b; \quad d = \sqrt{1+c^2}; \quad e = bde/bd; \quad f = bdf/bd; \quad g = bdg/bd;$$

$$h = \sqrt{1-(e^2+f^2+g^2)}; \quad j = bdhj/bdh; \quad k = bdhk/bdh; \quad m = bdhm/bdh;$$

$$n = \sqrt{1-(j^2+k^2+m^2)}; \quad p = bdhnp/bdhn; \quad q = bdhnq/bdhn; \quad r = bdhnr/bdhn;$$

$$s = bdhns/bdhn; \quad p^2+q^2+r^2+s^2 = 1 *$$

13 For 13 dimensions take the last 13 rows and columns and put  $c=1$ .

$$h = \sqrt{1-(e^2+f^2+g^2)}; \quad j = hj/h; \quad k = hk/h; \quad m = hm/h; \quad n = \sqrt{1-(j^2+k^2+m^2)};$$

$$p = hnp/hn; \quad q = hnq/hn; \quad r = hnr/hn; \quad s = \sqrt{1-(p^2+q^2+r^2)};$$

$$w = hns w/hns; \quad x = hns x/hns; \quad y = hns y/hns; \quad z = hns z/hns;$$

$$w^2+x^2+y^2+z^2 = 1 *$$

14 For 14 dimensions take the last 14 rows and columns and put  $a=1$ .

$$d = \sqrt{1-c^2}; \quad e = de/d; \quad f = df/d; \quad g = dg/d; \quad h = \sqrt{1-(e^2+f^2+g^2)};$$

$$j = dhj/dh; \quad k = dhk/dh; \quad m = dhm/dh; \quad n = \sqrt{1-(j^2+k^2+m^2)};$$

$$p = dhnp/dhn; \quad q = dhnq/dhn; \quad r = dhnr/dhn; \quad s = \sqrt{1-(p^2+q^2+r^2)};$$

$$w = dhns w/dhns; \quad x = dhns x/dhns; \quad y = dhns y/dhns; \quad z = dhns z/dhns;$$

$$w^2+x^2+y^2+z^2 = 1 *$$

15 For 15 dimensions the whole table is required.

$$b = \sqrt{1-a^2}; \quad c = bc/b; \quad d = \sqrt{1-c^2}; \quad e = bde/bd; \quad f = bdf/bd; \quad g = bdg/bd;$$

$$h = \sqrt{1-(e^2+f^2+g^2)}; \quad j = bdhj/bdh; \quad k = bdhk/bdh; \quad m = bdhm/bdh;$$

$$n = \sqrt{1-(j^2+k^2+m^2)}; \quad p = bdhnp/bdhn; \quad q = bdhnq/bdhn; \quad r = bdhnr/bdhn;$$

$$s = \sqrt{1-(p^2+q^2+r^2)}; \quad w = bdhns w/bdhns; \quad x = bdhns x/bdhns;$$

$$y = bdhns y/bdhns; \quad z = bdhns z/bdhns; \quad w^2+x^2+y^2+z^2 = 1 *$$

ORTHOGONAL TRANSFORMATIONS

a	-b	0	0	0	0	0	0	0	0	0	0	0	0	0
bc	ac	-d	0	0	0	0	0	0	0	0	0	0	0	0
bde	ade	ce	-f	g	-h	0	0	0	0	0	0	0	0	0
bdf	adf	cf	e	-h	-g	0	0	0	0	0	0	0	0	0
bdg	adg	cg	-h	-e	f	0	0	0	0	0	0	0	0	0
bdhj	adhj	chj	gj	fj	ej	-k	m	-n	0	0	0	0	0	0
bdhk	adhk	chk	gk	fk	ek	j	-n	-m	0	0	0	0	0	0
bdhm	adhm	chm	gm	fm	em	-n	-j	k	0	0	0	0	0	0
bdhnp	adhnp	chnp	gnp	fnp	enp	mp	kp	jp	-q	r	-s	0	0	0
bdhnq	adhmq	chnq	gnq	fnq	enq	mq	kq	jq	p	-s	-r	0	0	0
bdhnr	adhnr	chnr	gnr	fnr	enr	nr	kr	jr	-s	-p	q	0	0	0
bdhns	adhns	chns	gns	fn	ens	ms	ks	js	rw	qw	pw	-x	y	-z
bdhnsx	adhnsx	chnsx	gnsx	fn	ensx	msx	ksx	jsx	rx	qx	px	w	-z	-y
bdhnsy	adhnsy	chnsy	gnsy	fn	ensy	msy	ksy	jsy	ry	qy	py	-z	-w	x
bdhnsz	adhnsz	chnsz	gnsz	fn	ensz	msz	ksz	jsz	rz	qz	pz	y	x	w

4.

Certificate subject Physics and Chemistry.

(5) A weighted combination, of Mechanical Arithmetic and problem Arithmetic with the emphasis on the first mentioned will correlate high with Mathematics in Junior Certificate.

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THE RELATION OF SCHOOL SUBJECTS TO GENERAL INTELLIGENCE.

Science subjects appear to be largely dependant on only one of the factors in "General Intelligence" and therefore not affected by variations in the other components.

This hypothesis would be in line with the findings of Dr. E.M. Thompson<sup>1</sup> who studied the factors affecting school success in Std VII and Std IX.

"General Intelligence" was found to be important in both English and Mathematics and in the order stated.

Success in Physical Science (Std VII) however, depended to a limited extent on "General Intelligence" and this dependance became negligible by the time Std X is reached.

In the case of Biology (Std VII), it was found that "General Intelligence" constituted one of the less important factors determining success in this subject.

The finding of the present thesis that scientific subjects tend to be largely dependant on a unitary trait is similar also to the conclusions of F.M. Earle (3, pp45-46) who found, inter alia, that in the third year of high school science correlated positively only with Analogies and Reasoning tests; the correlations being .29 and .43 respectively.

<sup>1</sup>

Dr. E.M. Thompson: "Factors affecting school success"

(Unpublished Doctoral Thesis University of Cape Town). 1943 pp 109-119.

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DEPARTMENT OF PUBLIC EDUCATION.  
CAPE OF GOOD HOPE.

SPEED AND ACCURACY TEST.

(The invigilator must keep strictly to the time indicated above, or the test will be valueless.)

- Find the interest on £750 for 4 months at  $3\frac{1}{2}$  per cent.
- Write 8s. 6d. as the decimal of £1.
- Complete  $\frac{15}{6} = \frac{?}{20}$ .
- Simplify:  $\frac{.36 - .29}{.1575} \div \frac{.29}{.045}$ .
- A test comprised 5 questions each of 25 marks, and a pupil obtained 70 marks. What percentage of the marks did he obtain?
- At an election a candidate obtained 60 per cent. of the votes. If 900 people voted for him, how many voted altogether?
- What is the area of a triangle of which the base is 8 feet and the height  $1\frac{1}{2}$  yards?
- A bankrupt pays 10s. 3d. in the £; what will a creditor, to whom he owes £1,200, lose?
- If concrete costs 9 pennies per cubic foot, what will a piece 9 inches by 12 feet by 18 yards cost?

10.

£7-18-9	+	13-4 $\frac{1}{2}$	+	£65-1-0 $\frac{1}{2}$	=	?
£1-15-8 $\frac{1}{2}$	+	£150-1-6	+	£97-7-9	=	?
£5-6-7	+	£5-0-11	+	£7-7-7	=	?
?	+	?	+	?	=	?

DEPARTMENT OF PUBLIC EDUCATION.  
CAPE OF GOOD HOPE.

- A concrete block is  $2\frac{1}{2}$  ft. thick, 10 ft. wide and 12 ft. high. If  $\frac{1}{4}$ th of the block consists of cement, how many packets of cement 18 in. by 15 in. by 4 in. were needed to build the block?
- A certain alloy consists of three metals, A, B and C. A piece of the alloy contains the three metals in the following proportions: Weight of A =  $\frac{3}{5}$  of the total weight, weight of B =  $\frac{1}{5}$  of the total weight, weight of C = 14 lb. 1 oz. What is the total weight of the piece of alloy?

[Calculation to be done in decimals.]

- A man builds a house for £1,200. He pays £48 annually for repairs, insurance and taxes. He wants 6 per cent. interest on his money. What monthly rental must he charge for the house to cover both interest and running costs?
- A man buys a motor car for £500 and pays £100 cash as the first instalment. At the end of the first year he pays off £200 together with the interest on what he owes at 5 per cent. At the end of the second year he pays off the balance of what he owes, together with the interest on it at 5 per cent. What is the total amount he paid for the car?
- The front of a house consists of a triangular gable on a rectangular wall 12 ft. high. The top of the gable is 20 ft. above the ground and the wall is 30 ft. wide. The area of windows and front door is 30 sq. ft. Calculate the cost of painting the front of the house with two coats of paint at 13s. 6d. a gallon, given that one gallon of paint covers 15 sq. yds. for a single coat.
- A farmer has a crop of 2,000 boxes of apples of which 40 per cent. are first grade apples and the rest second grade. He sells the first grade apples at 7s. 6d. per box and the second grade at 6s. 9d. per box. The boxes cost him £49. 10s. per 1,000 and the packing materials 3d. per box. If the rest of the farming

- The cash transactions of a schoolboy for the second quarter of the year are as follows:—

7th April: Pocket money for the quarter, £1.  
 11th April: Bought a pair of football stockings, 5s. 6d.  
 15th April: Subscription for football club, 2s. 6d.  
 28th April: Sale of old racquet, 11s. 6d.  
 2nd May: Bought a football jersey, 10s. 6d.  
 12th May: Sale of woodwork model, £1. 10s.  
 25th May: Entry fees for sports, 3s. 6d.  
 4th June: Purchased camera supplies, £1. 5s.  
 12th June: Sale of snaps, 12s.  
 ∴ Petty expenses, 15s. 3d.

Draw up a cash account and show his balance at the end of the term.

- The graphs below represent the weights of two boys A (undotted line) and B (dotted line) from their 8th to their 16th year. Use these graphs to answer the following questions:—
  - What did B weigh when he was 13 years old?
  - How much heavier was B than A when they were 11 years old?
  - Between which years did A show the least increase in weight?
  - At what age did A and B have the same weight? What was this weight?
  - At what age did A and B show the biggest difference in weight and what was the difference?
  - What did A and B weigh at the age of 14 years?
  - What was the difference in weight between A and B at their 16th year?
  - At what age did B weigh 78 lb.?
  - What was the combined weight of A and B at the age of 10 years?

BIBLIOGRAPHY.

- (1) BURT, C : The relations of Educational Abilities. (British Journal of Educational Psychology Vol. 9, 1939). pp 45-70.
- (2) BURT, C : The Education of the Young Adolescent; The Psychological implications of the Norwood Report. (British Journal of Educational Psychology. Vol. 13, 1943). pp 126-140.
- (3) EARLE, F.M: Tests of Ability for Secondary School Courses. (University of London Press, London, 1936). pp 81-85.
- (4) FLANAGAN, J.C.: Factor Analysis in the Study of Personality (Stanford University Press, California, 1935). pp 28-37.
- (5) GOODMAN, C.H: Prediction of College Success by means of Thurston's Primary Abilities Tests. (Educational and Psychological Measurement. Vol. 4, No. 2 1944). pp 125-139.
- (6) JUDD, C.H: Psychology of High School Subjects. (Ginn & Company, Boston). 1915.
- (7) KELLEY, T.L: Educational Guidance. (Teacher's College, Columbia University, New York). 1914.
- (8) REYBURN & TAYLOR: Some factors of Intelligence. (The British Journal of Psychology vol, 31, part 3 1941). pp 250-261.
- (9) ROSS, C.C: How shall we predict High School Achievement?  
and HOOKS, N.T: (Journal of Education Research. vol 22, 1930).  
pp 184-196.
- (10) SMITH, H.W: A Differential Intelligence and Scholastic Test.  
(Unpublished Doctor's Thesis, University of Cape Town). pp 311-318.
- (11) THURSTON, L.L. & THURSTON, T.G. Factorial Studies of Intelligence. (University of Chicargo Press, Chicago, 1941) pp 35-38.
- (12) WOLF (Jr) R.R: Differential Forecasts of Achievement and their use in Educational Counseling. (Psychological Monographs. Vol. 51. No. 1. 1939) pp 1-51.
- (13) Encyclopedia of Educational Research: Prepared under the auspices of the Americal Educational Research Association. (The Macmillan Company 1941).
- THOMPSON, E.M: Factors affection School Success. (Unphblished Doctor's Thesis, University of Cape Town) .943.