CONTRACT REPORT

C/PERS 257

THE ASSESSMENT OF MENTAL ABILITY AMONG BLACK TEACHERS IN BOPHUTHATSWANA

Submitted to:

THE SACHED TRUST

NATIONAL INSTITUTE FOR PERSONNEL RESEARCH
COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

CSIR Contract Report C/PERS 257 (pp. i - v, 1 - 50)
UDC 159.928.23.072:371.12 (680=963)
Johannesburg, Republic of South Africa July 1977

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TEMPERAMENT AND PERSONALITY RESEARCH DIVISION

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Published by

National Institute for Personnel Research
Council for Scientific and Industrial Research
P O Box 10319
Johannesburg
Republic of South Africa 1977
2000

Printed in the Republic of South Africa by
National Institute for Personnel Research

ACKNOWLEDGEMENTS

This project was directed by Dr G. K. Nelson, Director of the National Institute for Personnel Research.

Other participants in the project steering committee included Mr M. A. Coulter, Head of Psychometric Methods and Test Construction, Mr V. I. Lätti, Head of Personnel Selection, Mr J. Verster, and Mrs M. A. Verster.

Mr P. Moikangoe and Mr M. N. Mahlaku assisted with the training of SACHED test administrators.

Data processing was undertaken in collaboration with Mr M. Muller of the Division of Psychometric Methods and the Computer Division at NIPR under the efficient supervision of Mrs Sheila Crossland.

The report was typed by Mrs G. Crawford-Nutt, and its production was supervised by Miss Barbara Tripp of the Temperament and Personality Research Division.

Appreciation is extended to Dr R. Lee, formerly of SACHED staff, and to Mr A. du Toit, at present of SACHED, who organized and conducted the complex field work of the two testing programmes which formed an essential part of the project.

Appreciation is also extended to the young men and women who comprised the teams of SACHED test administrators and who also learned the exacting discipline of scoring tests and preparing the data for loading into the computer. The young women included Misses C. Soko, W. Ngoma, L. Hlatshwayo, and L. Mokgata; and the young men, Messrs C. Nhlapo, J. Ralenala, E. Ramokoka, and C. Bodibe.

Special thanks are extended to Dr H Reuning, Head of Temperament and Personality Research, for encouragement and support in the execution of the project.

SUMMARY

As part of its programme to improve the qualifications of black Bophuthatswana teachers, SACHED Trust approached the NIPR for assistance with the assessment of the mental abilities of those participating in the courses it offered. Accordingly, a set of 19 reference tests was administered to a sample of the teachers in order to assess their reasoning, spatial, and number abilities, as well as their perceptual speed and language achievement.

Difficulties encountered in testing a sufficiently large number of subjects on the first attempt necessitated a second testing programme at a later date. The programmes produced test and biographical data on two samples of 101 and 184 subjects each.

In order to reduce sampling errors and capitalization on chance in the factor analysis, statistical grounds were sought for the combination of the test data from the two samples. These grounds could be obtained only by excluding two of the tests from the set. However, certain biographical data from the samples suggested that the data of the two samples could be combined on psychological grounds.

Confirmatory factor analyses were performed on the combined data to determine whether the 5 areas of cognitive functioning could be delineated by means of the reference tests that had been administered. When the results of all the attempts indicated that the data obtained in this study did not fit the model, an exploratory factor analysis was performed.

The exploratory factor analysis indicated that three latent variables were sufficient to determine the variance of the 5 test

groups administered, and that the latent variables were themselves correlated. The patterns of loadings of the tests on the latent variables rotated to simple structure suggested that an interpretation of the findings in terms of cognitive process theory might be helpful as the concept of 5 separate cognitive factors was inadequate in this case.

Examination of the results in terms of the contents and processes of the various memory stores provided information about the learning assets and deficits of the subjects that could be useful to the SACHED course writers in their attempts to understand the difficulties faced by some of those who enrolled for their courses.

A cluster analysis of the combined sample of subjects revealed that although it was possible to partition the subjects into subsamples according to their performance on the tests, and also to identify the subsamples in terms of age, sex, level of school education received, and type of teaching diploma attained, there was too much overlap among the samples on these variables for positive identification of individuals to be made.

Because graded courses of instruction were also not a practical solution to the problem of differential educational deficits among teachers enrolled for the courses, it is recommended that the course achievement tests that are to be constructed in a related project, be undertaken as soon as possible in order to enable SACHED course writers to introduce such changes in their materials as will enable them to help teachers make up their own educational deficiencies and thus help the children they teach to receive a more adequate education than is possible now.

CONTENTS

I N T R O D U C T I O N

In an article on the detection of ability in a multicultural community, H. J. Rousseau (1962) reflects the view that "Most people distrust test results, and prefer 'commonsense' yardsticks like performance on the job" (p.335). This view evokes particularly strong echoes in Southern Africa where test results have often failed to reflect the abilities of the black graduate "as these are suggested by his academic record, his performance at the selection interview, and by the quality of his performance in the real-life situation" (Crawford-Nutt, 1977, p.267).

What is meant by the failure of tests to reflect the true abilities of blacks who are tested on them is that the scores obtained by blacks on tests of mental ability are often considerably lower than those obtained by whites on the same tests. This difference in scores between blacks and whites has led to much controversy and to a re-appraisal of testing as a method of mental assessment.

The controversy concerns, of course, the alleged intellectual inferiority implied by the test results of blacks as compared with whites (Tobias, 1974; Vincent & Cox, 1974; Biesheuvel, 1972; Jensen, 1969, 1971, 1973).

In a critical survey of cross-cultural intelligence research in sub-Saharan Africa, Cryns (1962) has dealt with the controversy. He has discussed findings concerning the differences in brain shape, size, and fissuration between blacks and whites and has indicated that they are of no significance for intellectual differences. He has also indicated that although there are quantitative differences in the scores obtained by whites and blacks on mental ability tests

which cannot be gainsaid, the failure to achieve adequate controls for cross-cultural comparisons, makes the meaning of those differences hard to interpret. Cryns (1962) also indicates that the intelligence test score differences obtained between whites and blacks are not only quantitative, but are also qualitative. And he concludes that "The qualitative difference . . . found between White and African intelligence may well be the reflection within the individual mind of a basically different cognitive orientation of White and African culture" (p.297).

The implication of this finding for a new approach to and a new understanding of the measurement of the mental abilities of blacks has yet to calm the storm of controversy. But, for those ready to receive it, a suggestion about a new approach is already available, and has been for some time past.

In an article that has a direct bearing on the need for understanding the reality and the importance of the differences in mental functioning that result where human characteristics develop under widely differing cultures, Wolf (1964) has much of value to contribute. His paper on the measurement of environments was read at the third session of the 25th Invitational Conference on Testing problems held under the auspices of Educational Testing Service. The third session of that conference was devoted to testing the culturally "different".

Wolf's (1964) concern is with the importance of the environment in the production of those many individual differences that are measured by psychological tests. He is concerned that although "All theories of learning and behaviour make provision for the influence of the environment on the development of human

characteristics . . . we have not had a corresponding emphasis in our measurement procedures" (p.491).

The call is clearly for a greater awareness of the bases of individual differences and for more sensitivity in the use of tests and in the interpretation of test results. But the stress is still on measurement. Tests must still be used because other methods, such as waiting for evidence from "performance on the job" are too costly and come too late to be of much use in enhancing development. The so-called "practical" methods also depend too much on the subjective appraisal of the rater or observer using them to be fair to all individuals, or to provide information that is reliable and valid.

Accurate information is essential for the proper understanding of others. Or, as Biesheuvel (1962) expresses it more specifically, "If the talents of Africans are to be fully developed it is important that we should have more knowledge about the nature of these talents and the kind of stimulation that will bring them to their full development." (p.345).

Reliable and valid knowledge of the abilities that the individual should possess is an obvious necessity if he is to be so guided and assisted that he will benefit from a course of training or an educational programme and also experience a sense of self-fulfilment as a result of his participation in it. Such knowledge can be derived from a careful assessment of the particular mental skills of the individual as these have developed under the influence of his environment. An example of the kind of careful assessment of abilities suggested is indicated by J. B. Carroll (1974) of Educational Testing Service in a new approach to the understanding of the structure of the intellect.

Carroll (1974) makes the point that many of the elements of the cognitive tasks of everyday life are also to be found in the tasks presented to individuals in psychometric tests. As he puts it, "Writing a letter, planning a route, understanding the operation of a machine, thinking of a candidate for committee membership, learning a list of prices or ZIP codes - these are cognitive tasks which involve operations and strategies applied to various types of memory stores. These tasks are considered socially important; is it not important also to study the cognitive processes that underlie them?" (p.37).

The thinking, committing to memory, recalling, perceiving, imagining, and problem-solving activities required for everyday living are processes of the intellect by which individuals differ from one another in the degree of success they attain in conducting their lives, in profiting from experience, and in benefitting from training or educational courses offered to them. There is, of course, no simple relationship between those cognitive processes and the success of the individual in living. But in spite of its being complex, the relationship is there and can be used to predict the individual's probable success in life or on a training course or educational programme. It can also be used to investigate cognitive areas in which he lacks the necessary skills for success at learning or performing some activity.

Psychometric tests for measuring cognitive processes are, of course, already available, and with suitable analysis of the data obtained from their application, information can be obtained that will provide understanding of the individual's particular basic skills and give some indication of the areas in a training or

educational programme which need modification to enable him to develop the skills necessary for successful mastery.

It was with a view to obtaining this type of information that the South African Committee for Higher Education (SACHED) Trust approached the NIPR for assistance with the assessment of the mental abilities of the black teachers who were participating in its programme to improve their qualifications, and with the evaluation of the educational courses SACHED was offering to them.

From an instructional system point of view, the assessment and the evaluation projects occupy somewhat different positions in the system (Banathy, 1968). The project for the evaluation of the course materials aimed at producing achievement tests that would permit the evaluation of the effectiveness of particular courses. These tests would also enable SACHED to measure how well they were doing in their overall attempt to assist teachers in the improvement of their qualifications. Thus, the course evaluation project would provide SACHED with procedures it could use to monitor the efficiency and effectiveness of its instructional system.

The project to assess the mental abilities of the teachers who participated in SACHED's educational programme aimed at providing information to the course writers which if acted upon would ensure that the instructional methods used and materials offered were pitched at a level that would enable participants to derive the most benefit from them, and neither bore them through over simplification or tedious repetition, nor overwhelm with assumptions that they possessed more knowledge than they actually did, or would use methods they had never learnt. The teachers who enrolled for the courses offered by SACHED would very likely not be homogeneous in

either quality or quantity of educational background. They would also vary in sex, age, and years of teaching, and in other experience as well. They would thus bring to the courses not only a wide variety of skills, but also considerable variation in competence in the application of those skills.

On the basis of past experience in the administration of various tests, and in consultation with SACHED concerning particular problems experienced or anticipated by that organization, it was considered that the particular cognitive processes and abilities that should be investigated would include general reasoning ability, numerical ability, perceptual speed, and language achievement. The relationship of these cognitive areas to participation in educational courses should be apparent, especially if they are looked at from the point of view of the complex processing of information that they imply: memory input, search, and retrieval processes using the various memory stores; as well as, for instance, the identification and application of suitable algorithms in the solution of problems or in the understanding of relationships (Carroll 1974).

METHOD

Subjects

The subjects were male and female teachers who were enrolled for the educational courses offered by SACHED while they continued with their teaching duties. The full year's intake into the SACHED course in 1976 was to have constituted the sample. Unrest in the

country resulted in an initial sample of only 101 subjects who had taken all of the tests. In the light of the nature of the study envisaged, a larger sample was considered necessary, and an attempt was made in February 1977 to collect the balance of the sample. On this occasion data was collected from 184 subjects on all of the tests.

Analysis of the biographical data collected from the subjects indicated that there were certain differences between the two samples (See Table 1). For instance, the mean age of the first sample (N = 101) was 32.6 years (SD 8.2) and that of the second sample (N = 184) was 36.0 years (SD 8,5).

The approximately 4 years' difference in age in the two samples is reflected in a similar difference in their years of teaching experience. On average the first sample had had 9,7 years (SD 8.0) of experience as teachers, while in the second sample the number of years was 13,7 (SD 8,4). The difference in mean age and in years of teaching experience between the two groups is significant. For age, the difference is significant at $p < 0,001$ level ($t = 3,33$, df. 283), and for teaching experience the significance level is $p < 0,001$ ($t = 3,950$, df. 283).

Both samples had had about the same number of years of teacher training and the difference between them is not significant. The mean number of years of teaching experience of sample 1 was 2,2 (SD 0,73) and of sample 2, was 2,1 (SD 0,79) ($t = 0,749$, df. 283, $p = 0,46$). The sexes were equally represented in both samples and the level of schooling attained by both samples before they underwent teacher training was virtually the same. The average highest standard passed by the members of sample 1 was 7,7 (SD 0,70),

Table 1

Distributions of biographical data for two samples of black teachers

Biographical Information	Sample 1 (N = 101)				Observed Range		Sample 2 (N = 184)				Observed Range		(Diffs of Means) t
	Mean	SD	Skewness	Kurtosis	Max.	Min.	Mean	SD	Skewness	Kurtosis	Max.	Min.	
1 Age	32,56	8,20	0,834*	-0,058	57	20	36,04	8,48	0,467*	-0,208	68	22	3,334***
2 Sex	1,79	0,41	-1,461*	0,138	2	1	1,81	0,39	-1,592*	0,539	2	1	0,359
3 Top Std Passed +	7,66	0,70	-0,861*	1,164*	10	6	7,77	0,78	-1,110*	1,304*	10	6	1,125
4 Teacher Training	2,16	0,73	0,997*	9,377*	6	0	2,09	0,79	0,579*	7,441*	6	0	0,749
5 Teacher Experience	9,71	7,96	1,012*	0,413	35	0	13,75	8,36	0,581*	-0,531	36	0	3,950***
6 Other Work	0,25	0,75	3,842*	17,504*	5	0	0,20	0,91	5,328*	30,052*	7	0	0,516
7 Years in Area	15,16	12,60	0,959*	-0,239	51	1	15,31	13,09	1,271*	0,419	52	1	0,094

+ For Sample 1, N = 97

* p = 0,05

*** p = 0,001

and of sample 2 was 7,8 (SD 0,78) (t = 1,125, df. 279, p = 0,26).

The skewnesses of the distributions of the biographical variables presented in Table 1 are in the same directions for both samples. The positive skewnesses in both samples indicate that the ages of the subjects, as well as their amounts of teacher training, teaching experience, experience of work other than teaching, and the number of years they have lived in the area where they are teaching, all tend to fall towards the lower end of the range of each of these variables. The two negative skewnesses in both samples indicate, on the other hand, that in both samples the sex composition of the samples favours women, and the highest standard achieved at school was towards the upper end of the range. The significant kurtoses in the same three variables in both samples indicate that there is little variation among subjects about the mean values of the variables.

Materials

The tests that were administered to all of the subjects in both samples included the following:

1. Ravens Standard Progressive Matrices. The 1958 version of this well-known test of mental ability was used. A description of the test together with details of its scoring method as well as certain norm tables are to be found in Raven (1960).

2. Figure Classification Test. A121 (NIPR). This is a test of reasoning ability that requires the testee to

analyse sets of six figures into two groups on the basis of their inner relationships. The test is applicable to subjects with from 6 to 11 years of schooling.

3. Abstract Reasoning Test (Form T) (DAT). This test is from the Differential Aptitude Test battery of Bennett, Seashore, and Wesman (1974). The test is composed of abstract figure patterns. The task involves the ability of the subject to perceive the relationships among the nonlanguage designs, and requires him to think with abstract symbols as he educes and generalizes the operational principles.

4. Mental Alertness A/1/2 (NIPR). This is a 65-item composite test of intellectual ability designed to discriminate among subjects at the matriculation level of education. The test involves verbal reasoning ability to a considerable extent.

5. Figure Fitting Test (NIPR). This is a test of spatial ability which requires the testee to select from a choice of parts of figures that part which will complete a given figure. Selection of the correct part of a figure involves the ability to perceive, using mental manipulation and rotation, the shape and size of the required piece. The test has been administered to blacks in the educational range 8-10 years.

6. Blox Test (NIPR Perceptual Battery A80). This is a 45-item test of the subject's visualization ability,

and his ability to manipulate spatial relations. Representations of various configurations of from 2 to 4 cubes as seen from different perspectives are used to test the abilities mentioned.

7. Card Rotation (S-3 ETS). This test is one of those from the French, Ekstrom, and Price (1963) kit of reference tests for cognitive factors. It is intended to be a measure of the factor called spatial orientation which involves "The ability to perceive spatial patterns or to maintain orientation with respect to objects in space." (French et al., 1963, p.38).

8. Computation Test (Normal Battery NIPR). This is a 30-item test of the subject's ability to manipulate numbers in the arithmetical operations of multiplication and division when these are presented in sets of 5 problems first of one sort then of the other alternately, and a time limit is imposed. The test is intended for subjects in the 9 to 12 years of education range.

9. Numerical Ability. This 40-item test of the ability to understand numerical relationships and handle numerical concepts with ease is similar to that of the Bennett, Seashore, & Wesman (1966) Numerical Ability (Form L) of the Differential Abilities Test battery.

10. Addition Test (N-1, ETS). French et al., (1963) describe this test from their Kit as "a speed test of the addition of three 1- or 2-digit numbers" (p.28).

11. Subtraction and Multiplication (N-3, ETS). In the French et al., (1963) kit this test is described as a speed test of alternating sets of subtraction and multiplication items.

12. Division Test (N-2, ETS). This is a speed test of the ability to divide 2- or 3-digit numbers by single digit numbers (French et al., 1963).

13. Repeated Symbols (A/26/1, NIPR). This is a speed test of the ability to scan several pages of rows of symbols, pick out groups of identical symbols, and draw a ring round each group perceived.

14. Identical Pictures Test (P-3, ETS). This is a speed test of the ability to check rows of similar pictures against a model for each row and to mark that picture which is identical to the model (French, et al., 1963).

15. Maze Tracing Speed Test (Ss-1, ETS). This is a test of the ability to scan a series of mazes rapidly to reject false leads and to trace the open path through them (French, et al., 1963).

16. Vocabulary Test (NIPR, Normal Battery A76). This is a test of the ability to select the correct meaning for a given English word from among five possibilities. Thirty-six words are given in the test.

17. Comprehension Test (NIPR, Normal Battery A76). This is a test of the ability to comprehend written English and

to indicate such comprehension by selecting from five alternatives the correct response to a series of questions related to the passage presented to be read. Four passages are presented for reading and response.

18. Woordeskattoets (NIPN, Normale Battery, A76). This is a test of the ability to select the correct meaning for a given Afrikaans word from among five possibilities. Thirty-six words are given in the test.

19. Begripstoets (NIPN, Normale Battery A76). This is a test of the ability to comprehend written Afrikaans and to indicate such comprehension by selecting from five alternatives the correct response in a series of questions related to the passage presented to be read. Four passages are presented for reading and response.

20. Biographical Questionnaire. A comprehensive biographical questionnaire was presented to every subject for completion. The questions included those about age, sex, highest school standard passed, years of teacher training, years of experience in teaching, and so on.

Procedure

The 101 subjects of the first sample and the 184 subjects of the second sample were all tested on the 19 tests described previously, and all were given the biographical questionnaire to complete.

In order to collect the data most economically and with least disruption to the schools in the various far-flung areas in which the testees were teaching, the following considerations were taken into account:

The application of all of the tests and the biographical questionnaire required a day and a half to two days from each testee. Testing would have to be done at venues within fairly easy reach of teachers from schools in particular areas. The testers who would do the testing would be hired by SACHED specially for the task, and be trained by the NIPR for the job, but could not be expected to carry the sort of work-load to which experienced testers were accustomed.

The testing programme arranged thus included the training of six black male and female testers in two teams of three testers. In the team, two of the testers were trained to administer 6 of the tests each, and the third member was trained to administer 7 tests. The tests were allocated among the testers so that although one member of the team had 7 tests to administer, the time taken by each of the members of the testing team would be approximately the same.

In the field, a team of testers would all test the same group of testees. The group would be divided into two subgroups, and, over a period of two days, both subgroups would be tested on all 19 tests and also complete the biographical questionnaire.

After the testing was over, the unused testing material would be returned to the NIPR and the completed answer sheets and test protocols would be scored and the information on them entered on data sheets in readiness for loading into the computer. The testers hired by SACHED would be engaged to be trained by the NIPR to

prepare the data as indicated.

The programme worked as arranged, but because unrest in the country prevented the collection of data from a sufficient number of the year's enrolment of teachers in SACHED's courses, the entire testing programme, including the training of new testers and the re-training of those who had served on the first occasion, had to be repeated approximately five months later. But even then, the size of the combined sample of 285 subjects was considerably smaller than that expected at the start.

Statistical Analysis

Descriptive statistics of the usual biographical information and test performances of the two samples would be given for the comparison of the two samples. Intercorrelation matrices of test scores obtained on the same groups of tests by corresponding testers in the teams within sample 1 or 2 would be checked for equivalence of correlation patterns. Equivalence of patterns would suggest that the tests had functioned in the same way in the subsamples of testees tested by the teams and thus that the matrices obtained for the same groups of tests could be combined. If these conditions held for all three of the pairs of groups of tests administered by the two teams, then an intercorrelation matrix of all of the tests administered to a sample could be formed. When this had been done for both samples 1 and 2, their intercorrelation matrices on all of the tests could then be compared for equivalence, and if found to be equivalent, could be combined to provide input for an analysis of the cognitive factor structures underlying the performance of the teachers on the

various tests administered to them. Taken separately, only sample 2 with its sample size of 184 approaches the number of subjects per variable required to avoid excessive capitalization on chance in the factor analysis of 19 tests and so to provide a measure of confidence in generalizing findings to the population from which the sample was taken (Nunnally, 1967). Of course, if it is found that the tests had functioned in the same way in both samples 1 and 2, then combination of the intercorrelation matrices of both samples would be possible, and the resulting sample size of 285 subjects would increase confidence considerably in the results obtained from the factor analysis.

Since the cognitive factor structures considered necessary for subjects participating in the SACHED courses were specified at the start of the investigation and the set of tests to be administered to all subjects included those considered adequate reference tests of the specified factors, analyses of the obtained results would be made by means of confirmatory factor analysis. This procedure accords with Mulaik's (1972) comment that "In confirmatory factor analysis, the researcher formulates ahead of time a factor-analytic model about the latent variables which determine the variance of some observed variables and then tests the goodness of fit of this model to actual data" (pp. 365-366).

Once the cognitive factor structure measured by the set of reference tests used has been established, it will then be possible to select from those tests a smaller battery which will provide the user with information about the mental abilities of other samples of teachers from the same population.

R E S U L T S

As mentioned earlier, each sample was tested by two teams composed of three testers each. The 19 tests administered were divided into two subsets of six tests each and one subset of seven tests. Each tester in a team was responsible for one of the subsets of tests. In the two teams there were thus pairs of testers administering the same subsets of tests to different groups of testees.

In order to determine whether the test results obtained by corresponding pairs of testers could be combined to provide information about the whole sample, the intercorrelations of the tests within a subset was obtained for each group tested, and the equality of the correlation matrices from pairs of groups of subjects tested by corresponding testers, was investigated by means of Jennrich's (1970) chi-square test for the equality of two correlation matrices. The results for tester groups 1 and 2, 3 and 4, 5 and 6, of sample 1 are set out in Table 2. The same is done for sample 2 in Table 3.

The results show that the subsets of tests administered by corresponding pairs of testers did not function significantly differently in the groups of subjects they tested. None of the probabilities of obtaining the computed chi-square for the various pairs of correlation matrices reach significance at the 0,05 level. This meant that it was possible to combine results obtained from the groups tested on corresponding subsets of tests and to put all the results together to obtain an overall view of the performance of all of the subjects in a sample on all 19 tests. The combinations of test results are set out separately for the two samples in Table 4.

Table 2

Test intercorrelations within tester groups in Sample 1: first group below diagonal and second group above it

Tester Groups 1 and 2

Tests		1	2	3	4	5	6
Ravens	1		45	35	60	45	26
Vocabulary	2	50		49	20	46	43
Comprehen	3	37	46		28	19	18
Fig Fitt	4	53	33	05		31	18
Division	5	23	46	31	-07		71
Addition	6	03	38	18	-11	68	

Chisquare 11,9 df 15 p = 0,68

Tester Groups 3 and 4

Tests		1	2	3	4	5	6
Mental Al	1		56	57	19	01	54
Woordeskt	2	69		60	30	15	35
Begripst	3	61	42		33	09	29
Fig Clas	4	60	39	45		38	33
ID Pict	5	34	36	06	54		-03
Comp (NB)	6	70	70	47	54	38	

Chisquare 22,0 df 15 p = 0,11

Tester Groups 5 and 6

Tests		1	2	3	4	5	6	7
Abstr Res	1		35	26	40	40	14	50
Repeat S	2	40		05	41	32	32	28
Numb Abil	3	55	25		15	17	44	47
Blox	4	50	13	35		13	25	22
Maze Trace	5	47	62	37	33		23	39
Sub & Mult	6	43	21	60	32	40.		42
Crd Rotate	7	45	46	41	37	60	28	

Chisquare 25,2 df 21 p = 0,24

Chisquare test for equality of correlation matrices is shown beneath each pair of correlation matrices.

Decimal points omitted from correlations within matrices.

Table 3

Test intercorrelations within tester groups in Sample 2: first group below diagonal and second group above it

Tester Groups 1 and 2

Tests		1	2	3	4	5	6
Ravens	1		36	51	56	19	30
Vocabulary	2	29		28	19	30	17
Comprehen	3	31	40		36	15	27
Fig Fitt	4	53	29	15		19	22
Division	5	15	31	28	-13		58
Addition	6	27	19	28	-03	57	

Chisquare 17,2 df 15 p = 0,31

Tester Groups 3 and 4

Tests		1	2	3	4	5	6
Mental Al	1		39	50	40	26	45
Woordeskt	2	40		63	64	37	20
Begripst	3	40	41		44	20	32
Fig Clas	4	42	33	29		57	18
ID Pict	5	28	31	22	57		-02
Comp (NB)	6	49	28	19	24	16	

Chisquare 17,6 df 15 p = 0,28

Tester Groups 5 and 6

Tests		1	2	3	4	5	6	7
Abstr Res	1		13	54	24	48	-08	15
Repeat S	2	36		24	16	39	30	33
Numb Abil	3	49	28		34	48	32	29
Blox	4	16	41	21		34	11	26
Maze Trace	5	42	40	27	44		10	43
Sub & Mult	6	13	26	49	09	05		29
Crd Rotate	7	25	43	35	25	27	31	

Chisquare 19,3 df 21 p = 0,56

Chisquare test for equality of correlation matrices is shown beneath each pair of correlation matrices.

Decimal points omitted from correlations within matrices.

Table 4

Distributions of test data for two samples of black teachers

Tests	Sample 1 (N= 101)				Observed Range		Sample 2 (N= 184)				Observed Range		(Diffs of Means) t
	Mean	SD	Skewness	Kurtosis	Max.	Min.	Mean	SD	Skewness	Kurtosis	Max.	Min.	
1 Raven's	34,35	10,37	-0,420	-0,464	54	11	33,92	8,70	-0,396*	-0,290	53	12	0,351
2 Mental Alert	13,92	5,66	0,400	0,519	31	2	14,14	5,06	0,121	-0,462	26	2	0,336
3 Abstr Reason	15,22	8,62	0,686*	-0,524	40	3	14,00	8,54	0,864*	0,081	39	3	1,149
4 Figure Class	19,58	6,61	-0,088	-0,457	35	5	19,29	6,01	-0,197	-0,392	31	3	0,383
5 Blox	14,41	5,44	0,378	0,226	30	3	14,71	4,91	0,588*	0,535	31	4	0,482
6 Figure Fitt	22,58	7,95	0,253	-0,808*	42	9	22,38	8,39	0,068	-0,792*	41	4	0,204
7 Card Rotation	98,22	28,95	0,363	0,178	177	29	103,82	28,02	0,380*	0,888*	214	39	1,589
8 Comput (Norm Bat)	13,67	4,98	-0,056	0,003	25	1	13,98	4,57	0,158	-0,306	26	4	0,520
9 Number Ability	14,29	6,25	1,044*	1,876*	38	3	14,16	6,13	0,774*	0,422	35	4	0,169
10 Addition	34,74	9,87	0,526*	0,414	64	11	32,08	8,32	0,385*	0,217	60	15	2,293**
11 Division	30,94	13,51	0,578*	1,016*	80	2	31,36	11,00	0,152	-0,121	58	5	0,269
12 Sub & Multiply	39,65	13,10	0,118	-0,452	73	10	41,82	13,66	0,513*	0,605	98	15	1,292
13 Repeat Symbol	68,43	18,36	-0,286	0,367	113	9	69,70	16,37	0,118	-0,133	116	29	0,600
14 ID Pictures	51,08	14,59	0,115	1,248*	73	14	44,65	11,07	-0,369*	0,194	73	14	3,846***
15 Maze Tracing	9,75	3,34	0,070	-0,319	20	0	8,90	4,89	0,217	-0,167	24	0	1,465
16 Vocabulary	24,30	3,90	-1,320*	5,166*	32	5	23,98	4,15	-0,577*	0,868*	35	8	0,620
17 Comprehension	12,91	2,65	-0,423	0,177	18	5	12,38	2,63	-0,142	-0,537	18	5	1,620
18 Woordeskat	18,36	4,65	-0,166	0,684*	34	5	17,97	5,39	-0,338	0,011	33	2	0,609
19 Begripstoets	12,28	3,32	-0,531*	0,909*	19	0	12,82	2,97	-0,386*	0,139	20	3	1,412

* p = 0,05 ** p = 0,02 *** p = 0,001

Table 4 shows the means, standard deviations (SDs), skewnesses, kurtoses, and ranges of the distributions of scores obtained for each of the two samples of teachers. Abbreviated titles of the tests that were administered are shown in the extreme left-hand column of the table, then come six columns of details concerning sample 1, then those of sample 2, and finally, in the extreme right-hand column are the values of the t-tests of the significance of the differences in the means obtained in the two samples. There was no missing data in the test results in either sample, which means that for 283 degrees of freedom for the t-tests, the obtained t = 2,293 for the differences between the two samples in the means of the scores on the Addition test and the t = 3,846 for the differences in the means of the Identical Pictures tests are highly significant, the first at p = 0,02, and the second at p = 0,001.

Apart from showing the significant differences just indicated between the two samples, Table 4 contains information about the shapes of the distributions which indicate whether scores were normally distributed about the mean or whether they tended to bunch towards the upper or lower ends of the ranges of scores, and how tight the bunching was.

The skewness of a distribution of scores indicates its tendency to bunch one way or the other. Negative skewness indicates the relative easiness of a test for the testees, and positive skewness its relative difficulty. Kurtosis indicates, in a general way, the density of the spread of scores around the mean. Negative Kurtosis indicates a lower density of spread than is found in a normal distribution, and positive Kurtosis a higher density.

In sample 1 only the score on the Vocabulary and Afrikaans

comprehension tests tended to bunch towards the upper end of the range. This is indicated by the significant negative skewnesses of those two test score distributions. All the other significant skewnesses in that sample are positive and indicate that for the tests concerned, namely, Abstract Reasoning, Numerical Ability, Addition, and Division, the tendency was for scores to bunch towards the lower ends of the ranges.

Tight bunching of scores is indicated by significant positive kurtoses, and the higher the positive value the more scores there are bunched together. On the Numerical Ability, Division, Identical Picture, Vocabulary, Woordeskat, and Begrips tests, the scores obtained tended to bunch from a moderate to a high degree of density around the mean, whereas the bunching of scores on the Figure Fitting Test tends to be less dense than would be found in a normal distribution because the kurtosis of the distribution of scores on that test is significantly negative.

In Sample 2, very often different tests from those in Sample 1 are positively or negatively skewed, and have different positive or negative kurtoses. This indicates that even where there are not significant differences between the means of the two samples, the members of the two samples tended to vary somewhat in their responses as a group to some of the tests. Too much must not be made of these differences, however, because the sensitivity of the test of significance used is a function of sample size, and the two samples were not the same size. An indication of this can be found by looking at the skewness of the distribution of the two samples on the scores of the first test in Table 4, the Raven's test. There an asterisk indicates that the value of -0,396 for sample 2 is

significant at p = 0,05, while the larger absolute value of sample 1, namely -0,420 is without an asterisk and is thus indicated as not significant and could have been obtained by chance. The greater sensitivity of the test for a sample size of 184 as against one of 101 accounts for this finding. Nevertheless the finding on the Raven's test in sample 2 suggests that a similar trend is discernible in sample 1.

Although it was evident that there were differences between the test scores of the two samples of teachers tested on the 19 selected tests, the possibility of combining the two sets of data was examined with a view to obtaining as large a number of subjects as possible for the investigation of the functioning of the tests in the population of teachers from which the samples were drawn.

To test whether the 19 tests administered to both samples functioned in the same way in the two samples, the test scores for sample 1 were intercorrelated and the same was done for sample 2. The two matrices were then tested for equality by means of Jennrich's (1970) chi-square test.

The results showed that where the two tests, the Addition test and the Identical Pictures test were included in the matrices, the difference found between the two matrices was likely by chance only once in a hundred times. That highly significant difference meant that on statistical grounds the data from the two samples should not be combined.

When the Addition and Identical Pictures tests were excluded from the matrices and the two were then tested for equality, the difference between them was found to be statistically insignificant and the data from the 17 tests could be combined.

Table 5 sets out the intercorrelation matrices of the two samples on the 19 tests and indicates the results of the two applications of the Jennrich's (1970) test. The correlation matrices of the two samples are set out on either side of the diagonal. That for sample 1 is below the diagonal, and that for sample 2 is above it. The starred correlations in both matrices are the only ones that are insignificant, all the rest are significant. Differences in the sizes of significant correlations in the two samples are a function of the sizes of the samples, the larger sample size permitting discrimination at lower levels of correlation.

The correlations between certain biographical variables and the tests administered to the two samples are set out in Table 6. The biographical variables include the age, sex, and highest school standard achieved by the subjects, as well as the number of years a subject has lived in the area where he is teaching, the number of years of teacher training received, and the number of years of teaching experience gained. The correlations for the two samples separately are given for all 19 tests, but for the combined samples the correlations given exclude the two tests which were found to differ significantly between the samples on their mean scores.

The negative correlations between age and test scores indicate that younger people tend to obtain higher scores. The negative correlation between teaching experience and test scores means much the same except that in the case of a few tests such as arithmetic and English vocabulary, years of experience and scores on the tests do tend to go together somewhat. The highest school standard attained by a subject would be expected to correlate positively with scores on a test, if they correlated at all, and this is what is found in

Table 5

Combined intercorrelation matrices+ of the tests administered to both samples of black teachers:

Sample 1 matrix (N = 101) is below the diagonal, and Sample 2 matrix (N = 184) above it

Tests		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Raven's	1		46	58	66	28	55	27	25	51	29	17	15	27	42	44	33	43	49	33
Mental Alrt	2	51		47	41	25	29	20	48	60	36	39	37	21	27	36	55	43	40	45
Abstr Reasn	3	58	40		50	22	46	19	13*	52	13*	04*	01*	21	33	46	33	35	40	35
Fig Class	4	73	44	54		34	55	35	22	51	27	15	15	41	57	49	27	42	48	36
Blox	5	33	16*	46	33		33	26	12*	30	15	07*	10*	25	27	38	20	28	26	17
Fig Fitt	6	56	26	49	52	42		26	15	40	13*	05*	02*	45	47	39	25	27	35	30
Crd Rotate	7	40	25	46	53	30	40		17	32	33	10*	30	37	34	37	04*	24	14*	16
Comput (NB)	8	41	61	28	44	18*	26	20		53	48	60	59	10*	09*	10*	22	24	26	25
Numba Abil	9	45	58	46	53	28	29	42	62		37	42	38	25	33	40	42	45	49	40
Addition	10	11*	29	16*	15*	07*	-02*	23	53	34		57	70	26	27	20	18	27	18	22
Division	11	30	42	23	34	19*	06*	29	66	56	71		70	16	14*	04*	30	20	26	24
Sub & Mult	12	33	50	31	38	29	29	35	69	53	51	64		28	10*	08*	19	24	16	14*
Repeat Sym	13	35	26	37	39	25	36	37	07*	16*	05*	11*	26		47	39	12*	15	18	15
ID Picture	14	36	06*	27	41	30	40	23	14*	16*	-02*	08*	23	30		43	13*	25	33	21
Maze Trace	15	48	37	43	49	24	39	49	20	28	11*	17*	32	46	27		21	35	33	31
Vocabulary	16	44	51	24	44	21	26	26	57	36	36	43	48	25	28	39		33	41	46
Comprehen	17	32	41	23	34	05*	14*	25	44	37	21	27	32	10*	04*	15*	48		33	30
Woordeskat	18	44	65	44	35	26	24	35	51	50	26	30	39	20	13*	41	50	44		51
Begripst	19	37	58	26	39	11*	18*	17*	37	37	18*	23	35	21	06*	44	48	36	51	

*NOT significant at 0,05 level.

+ Decimal points omitted.

For all 19 tests : X^2 = 288,2 df 171 p = 0,009

Tests 10 & 14 out: X^2 = 152,2 df 136 p = 0,152

On Jennrich (1970) test for equality of matrices

Table 6

Intercorrelations of biographical and test data for the two samples of black teachers

Tests	Sample 1 (N = 101)						Sample 2 (N = 184)						Samples 1 and 2					
	Age	Sex	Std	Liv	TT	TE	Age	Sex	Std	Liv	TT	TE	Age	Sex	Std	Liv	TT	TE
Raven's	-35*	-03	27*	-15	-12	-25*	-35*	-14	23*	-24*	-03	-22*	-35*	-10	24*	-20*	-07	-23*
Mental Alrt	-13	-29*	34*	-12	01	-11	-13	-20*	18*	06	-06	-05	-12*	-24*	26*	-01	-04	-07
Abstr Reason	-46*	-12	24*	-19	-24*	-39*	-35*	-23*	16*	-19*	-08	-32*	-39*	-19*	18*	-19*	-12*	-35*
Fig Class	-32*	03	31*	-20*	09	-21*	-43*	-11	23*	-21*	-01	-30*	-39*	-06	25*	-21*	-05	-27*
Blox	-20*	-03	05	-09	-24*	-22*	-28*	-30*	13	-06	05	-16*	-24*	-20*	08	-07	-07	-17*
Fig Fitt	-34*	03	12	-11	-15	-35*	-28*	-18*	07	-11	03	-22*	-30*	-11	09	-11	-03	-26*
Crd Rotate	-29*	-14	19	-02	-18	-25*	-26*	-08	13	-05	-03	-16*	-25*	-10	17*	-04	-08	-16*
Comput (NB)	12	-11	20*	-21*	17	17	10	-15*	00	06	05	14	11	-14*	11	-04	06	15*
Numba Abil	-17	-23*	27*	-10	-07	-16	-24*	-39*	24*	-10	-07	-21*	-21*	-33*	23*	-10	-10	-19*
Addition	24*	-03	17	-20*	27*	27*	-01	10	-02	-13	10	11	-	-	-	-	-	-
Division	09	-01	18	-18	10	17	09	-10	-01	02	02	16*	09	-06	10	-06	01	16*
Sub & Mult	01	03	06	-07	08	08	18*	01	-06	00	08	25*	14*	01	02	-02	06	20*
Repeat Sym	-18	22*	-01	05	-19	-14	-19*	04	-03	-03	05	-09	-17*	11	-01	-00	-07	-09
ID Pictures	-26*	13	24*	-16	-23*	-14	-43*	05	06	-16*	07	-30*	-	-	-	-	-	-
Maze Trace	-35*	00	25*	-07	-08	-34*	-38*	-26*	21*	-17*	-11	-35*	-38*	-17*	19*	-14*	-13*	-35*
Vocabulary	13	00	22*	-10	18	20*	05	-26*	09	-01	01	10	07	-17*	13*	-04	03	12*
Comprehen	-09	04	14	-09	12	-13	-22*	-15*	05	-03	-02	-09	-19*	-08	07	-05	01	-12*
Woordeskat	-20*	-33*	45*	-11	02	-20*	-24*	-25*	20*	-26*	01	-24*	-23*	-27*	29*	-21*	-01	-23*
Begripst	-10	-07	20*	-12	06	-16	-05	-14	17*	-15*	04	-05	-05	-11	19*	-14*	02	-07

Decimal points omitted in matrices. Std = Highest School Standard passed. TT = Years of Teacher Training.
* Significant at 0,05 level. Liv = Years lived in area where teaching. TE = Years Teaching Experience.

both samples. It is interesting to notice that although the sex composition of both samples is virtually the same, in sample 2 more so than in sample 1, there is a tendency for males to obtain higher scores than females on tests that correlate significantly with sex. Another interesting observation is that compared with the tests of reasoning ability, spatial ability, and perceptual speed, age and the ability to do most of the number tests are not related. In sample 1 the exception is the Addition test, in which age and a high score are significantly positively correlated, and in sample 2 the Subtraction and Multiplication test is significantly positively correlated with age, but the Numerical Ability test is correlated with youth.

Returning now to the finding that the test data of the two samples could be combined on statistical grounds, provided that the data from the Addition and Identical Pictures tests were excluded from both samples, the next step was to examine whether the groups of tests remaining measured the general reasoning ability, spatial ability, numerical ability, perceptual speed, and language achievement of the total sample of black teachers as intended. If each of these cognitive abilities is conceived of as a latent variable which is determining the variance of the particular tests selected to measure it, then a confirmatory factor-analytic model can be used to test the goodness of fit of the data obtained from the tests to the factors they are intended to measure (Mulaik, 1972). The particular model used in this study is that based on Jöreskog's (1969) general approach to confirmatory maximum likelihood factor analysis.

In keeping with the concept of 5 separate cognitive areas measured by 5 groups of reference tests, a restricted orthogonal

solution was called for. The results appear in Table 7. The title of the solution appears towards the foot of the left-hand layout. With 83 restrictions, the chi-square for the solution is X^2 = 910,410, df. = 119, and the probability that the obtained data fits the model is zero.

To test the possibility that the 5 groups of tests were indeed measuring the 5 cognitive factors but that the factors, instead of being orthogonal were related to one another, a restricted oblique solution was called for. With 73 restrictions (the factors now being free to correlate), a chi-square of 384,44, df. = 109, there was a slight improvement in the fit of the data to the model, but the probability of an acceptable fit was still found to be zero. The details appear in the middle columns of Table 7.

To test the possibility not only that the factors might be related, but also that language achievement loaded on the factors of reasoning, number, and perceptual speed but not on spatial ability, a 4 factor restricted solution was called for. The changes reduced the number of restrictions to 47, produced a chi-square of 399,93, df. = 105, but again, a zero probability that the obtained data fits the model. The right-hand columns of Table 7 give the details.

The meaning of these results was that the three attempts to confirm the presence of clearly defined separate factors of cognitive functioning by means of the set of tests administered to this sample of subjects had proved to be quite unsuccessful. Within the solutions obtained there are indications that the tests in each group load unequally on their factors and that the factors themselves are not separate but have elements in common which confound them.

Table 7

Confirmatory factor analyses of data from combined samples of black teachers (N = 285) on 17 tests

Tests		I	II	III	IV	V	I	II	III	IV	V	I	II	III	IV
Raven's	1	86	0	0	0	0	80	0	0	0	0	77	0	0	0
Ment Alrt	2	57	0	0	0	0	64	0	0	0	0	65	0	0	0
Abstr Reasn	3	67	0	0	0	0	68	0	0	0	0	67	0	0	0
Fig Class	4	79	0	0	0	0	80	0	0	0	0	78	0	0	0
Blox	5	0	58	0	0	0	0	47	0	0	0	0	45	0	0
Fig Fitt	6	0	62	0	0	0	0	67	0	0	0	0	68	0	0
Crd Rotate	7	0	48	0	0	0	0	53	0	0	0	0	52	0	0
Comput (NB)	8	0	0	80	0	0	0	0	82	0	0	0	0	82	0
Numba Abil	9	0	0	62	0	0	0	0	69	0	0	0	0	69	0
Division	10	0	0	80	0	0	0	0	77	0	0	0	0	77	0
Sub & Mult	11	0	0	79	0	0	0	0	75	0	0	0	0	75	0
Repeat Sym	12	0	0	0	64	0	0	0	0	57	0	0	0	0	51
Maze Trace	13	0	0	0	64	0	0	0	0	72	0	0	0	0	66
Vocabulary	14	0	0	0	0	66	0	0	0	0	65	2,31	0	-26	-1,74
Comprehen	15	0	0	0	0	51	0	0	0	0	56	1,32	0	-07	-0,83
Woordeskat	16	0	0	0	0	70	0	0	0	0	71	2,26	0	-31	-1,55
Begripst	17	0	0	0	0	69	0	0	0	0	65	2,64	0	-45	-1,96

		I	II	III	IV	V		I	II	III	IV	V		I	II	III	IV
Factor Intercor-relations	I	1,00					I	1,00					I	1,00			
	II	0	1,00				II	91	1,00				II	94	1,00		
	III	0	0	1,00			III	54	43	1,00			III	57	42	1,00	
	IV	0	0	0	1,00		IV	80	96	32	1,00		IV	95	1,00	35	1,00
	V	0	0	0	0	1,00	V	80	59	62	61	1,00					
Maximum-likelihood solutions		Restricted Orthogonal (m = 83) X^2 = 910,41 df 119 p = 0,00						Restricted Oblique (m = 73) X^2 = 384,44 df 109 p = 0,00						Restricted Oblique (m = 47) X^2 = 388,93 df 105 p = 0,00			

Decimals of factor loadings omitted

In order to investigate what latent variables underlay the set of tests administered in this study, an exploratory factor analysis was decided upon. The New NF47A and NF47B programmes used at the NIPR for exploratory factor analysis are based upon Kaiser's (1974) Little Jiffy, Mark IV. The method assesses the sampling adequacy of the data (MSA), and provides an improved estimate of the number of factors to be extracted. In applying the technique to the present data it was decided to investigate each sample separately as well as together, and to include all 19 tests in the analysis. The reason for including the two tests which differed significantly in their means across the samples is that while there is no statistical justification for combining the data from the two samples with these tests included, there are sound psychological reasons for doing so. It will be recalled from the information summarized in Table 1 that the mean ages of the two samples also differed significantly. Although the effect of age upon the intellectual and physical performance of the individual subject is a complex function of a number of social and personal variables (Schaie and Labouvie-Vief, 1974) which precludes any easy predictions about the performance of individuals selected from among a group, over the past half century "a pattern of general and differential intellectual decrement appears to have emerged as one of the best replicated findings in psychological gerontology" (Ibid, p.305). This means that it is possible that age and age-linked variables such as time, place, and type of teacher training, as well as teacher experience and general educational and personal history and so on, could account for certain basic differences between the two samples. And, since these personal and social variables are present in the population of subjects from which the

two samples were drawn, it seems permissible on psychological grounds to combine the data from them. But as a precaution against a serious error of judgment here, the samples will be factor analysed separately as well.

Application of Kaiser's (1974) Little Jiffy, Mark IV, programme to the data produced MSA's of 0,89 for samples 1 and 2 separately, and 0,91 for the two samples combined. Kaiser's programme describes MSAs in the 80s as 'meritorious', and in the 90s as 'marvellous', thus the data in the present study may be regarded as quite adequate for the purpose of factor analysis.

The number of factors which Kaiser's (1974) programme estimated should be extracted is 3. Two-factor and four-factor solutions were looked at as well, but the improvement in the factoring of the Little Jiffy, Mark IV, method of estimation was evident in the better interpretability of the three-factor solution.

In his discussion of the rotation of factors in factor analysis, Mulaik (1972) remarks that "The intercorrelations among factors obtained from simple structure solutions . . . indicate the presence of latent variables which are confounded with other latent variables. Hence intercorrelation among factors may be useful in interpreting the factors" (p.227). In other words, to obtain the best definition of both correlated and uncorrelated patterns of interrelated variables, an oblique rotation of the factors is an advantage (Rummel, 1970; Harman, 1976).

A direct quartimin rotation to 3 factors of the data was thus obtained from the administration of the 19 tests to the two samples of black teachers and is set out in Table 8. The solution for the combined data is given on the right-hand side of the table, and that

Table 8

Direct quartimin rotation to 3 factors of data obtained from the administration of 19 tests to two samples of black teachers

Tests	Sample 1 (N = 101)			Sample 2 (N = 184)			Samples 1 and 2		
	1	2	3	1	2	3	1	2	3
Raven's	63*	31	-03	50*	41*	-05	43*	49*	-06
Mental Alert	03	74*	13	66*	00	25	68*	-00	21
Abstr Reason	63*	14	01	59*	25	-20	44*	41*	-16
Figure Class	70*	18	08	36*	59*	-06	31	62*	-02
Blox	53*	-09	10	17	59*	-01	09	41*	02
Figure Fitt	71*	02	-08	29	54*	-16	17	62*	-14
Card Rotate	62*	-04	15	-10	55*	19	-09	55*	20
Comput (NB)	-01	40*	61*	31	-09	63*	36*	-08	62*
Number Abil	25	30	41*	60*	16	26	51*	18	29
Addition	-09	-03	79*	-01	26	70*	-00	10	69*
Division	05	-01	85*	18	-08	76*	14	-05	76*
Sub & Multiply	17	15	63*	-04	10	86*	01	09	79*
Repeat Symbol	54*	04	-07	-14	67*	14	-15	64*	11
ID Pictures	57*	-13	00	05	67*	-02	-04	62*	-01
Maze Tracing	51*	29	-11	25	52*	-09	21	54*	-08
Vocabulary	11	50*	23	25	52*	-09	61*	-04	11
Comprehension	-02	53*	11	43*	17	11	46*	10	09
Woordeskat	06	72*	03	60*	11	01	63*	09	01
Begripstoets	-00	73*	-08	60*	-01	04	64*	-02	00

		1	2	3		1	2	3		1	2	3
Factor	1	1,00			1	1,00			1	1,00		
Correlation	2	0,45	1,00		2	0,44	1,00		2	0,48	1,00	
Matrices	3	0,27	0,45	1,00	3	0,24	0,16	1,00	3	0,34	0,21	1,00

* Loadings greater than 0,35 for clarity of factor delineation
Decimals omitted from loadings

for the two samples, separately, to the left of that. The test groups for reasoning ability, spatial ability, numerical ability, perceptual speed, and language achievement are delineated by means of horizontal dotted lines. The group of reasoning tests is at the top, and the other test groups follow in sequence down the table. The loadings of the tests on the 3 factors are highlighted by starring those loadings which are greater than 0,35. This highlighting enhances the definition of the latent variables.

How much confidence can be placed in the definition of the latent variables obtained in a particular study depends upon, among other things, the degree of sampling error and the extent to which chance plays a role in the analysis of the factors. Since both sampling error and capitalization on chance are reduced by the use of large numbers of subjects (Nunnally, 1967; Harman, 1976), more confidence can be placed in the results obtained from combining samples 1 and 2 in the present study than from those obtained from the separate samples. Interpretation will thus be based mainly on the results of the combined samples, with the results of the separate samples providing only additional tentative information.

The loadings of the tests on the three latent variables extracted by the method of factor analysis used in this study are given in the data for the combined samples 1 and 2 in the right-hand column of Table 8. The patterns of loadings and the factor correlation matrices indicate that the three latent variables extracted are intercorrelated, and that while three of the test groups load on single latent variables, two of the test groups have within them complex tests which load on two latent variables, as well as tests which load on different latent variables.

The loadings of 5 test groups on only 3 latent variables suggests considerable overlap, in this study, in the cognitive areas covered by the test groups. Even in the 4 factor solution, which was looked at but which was not tabled, it was found that three latent variables accounted for the significant loadings and resulted in the overlap of cognitive areas already noticed. In other words, the latent variables that have been extracted in this study are best conceived of not as cognitive factors in the usual sense, but rather as embodying cognitive processes as these have been discussed and analysed by Carroll (1974).

From the results of the combined data of samples 1 and 2 as these are set out in the right-hand column of Table 8, it is clear that latent variable number 3 concerns facility with numbers. In looking at the loadings of the test in this group it is important to notice that the Number Ability test does not load as heavily as do the others on the latent variable. The reason is that this test makes different demands upon the cognitive processes from those made by the rest of the tests in the group. The other tests in the number test group rely mainly upon whether the subjects have learnt the numbers and numerical operations of the number system and thus have number associations and algorithms stored in their long term memories which they can retrieve and use easily and quickly to perform serial operations in the solution of numerical problems. The Numerical Ability test, on the other hand, while it also requires these cognitive processes, has in addition the strong requirement that the testee has learnt algorithms for quantitative relations and has stored these in his long term memory, and can retrieve and use them in the reasoning task that forms part of the problem presented by the items of this test.

Because the Numerical Ability test requires the testee to reason, it would be expected that the test would associate with other tests that also have this requirement. Latent variable number 1 shows that it does. There the Numerical Ability test loads with the Raven's, Mental Alertness, and Abstract Reasoning tests. Those three tests all have the requirement that the testee either retrieves word meanings or logical algorithms, and searches hypotheses, and then performs serial operations with the contents of the memory store on the stimulus materials.

The language achievement tests, and the arithmetic computation test also load on latent variable 1 and indicate that that variable determines the variance of tests involving other cognitive processes in addition to those mentioned in the previous paragraph. The computation test, for instance, indicates that the latent variable also includes the cognitive processes of the retrieval of number associations and algorithms from long term memory, and the performance of serial operations with the algorithms. The language achievement tests indicate that the search for instances, as well as the retrieval of word meanings and logical algorithms stored in long term memory, and the performance of serial operations with the memory content, all form part of the first latent variable.

The loading of two of the tests from the reasoning ability test group on latent variable 2 as well as on latent variable 1 indicates that this variable shares aspects with the first latent variable at the same time as embodying cognitive processes not included in the other two. It is perhaps important to notice that the three reasoning tests which load on latent variable 2 are the geometrico-pictorial tests which present the testee with reasoning problems in

non-language pictorial format. The other test groups loading on this latent variable are the spatial ability tests and the perceptual speed tests. The cognitive processes embodied in this variable include those associated with the short term memory store and what Carroll (1974) calls the sensory buffers. In perceptual speed there is no question of retrieval from memory but rather a search in limited time for lines or paths or specified items. The spatial aspect of the latent variable includes the mental rotation or manipulation of visual stimuli and in some instances the performance of serial operations, making use of the short term memory store in the process. The tests from the reasoning test group that load on this latent variable seem to do so because they require the testee to employ his short term memory store to respond to the visual stimuli presented to him, and to search hypotheses in his long term memory store, using the contents of this store to perform serial operations to solve the reasoning problems presented to him pictorially.

The analysis of the three latent variables just given, provides an assessment of the mental abilities of the sample of black teachers in terms of the set of 19 tests administered to them. The similar loadings of quite disparate test groups upon the same latent variables, and the loadings of some of the tests on more than one latent variable, suggest that it would be difficult to interpret with confidence any data obtained from a short battery of tests derived from the present set of 19 tests and applied to future samples of black teachers without much further research. Since the basic aim of the project was to enable SACHED to improve its course material in the light of the information about the mental abilities of its course participants, it might be more profitable to consider in

further detail the information that has come to light about the mental abilities of the sample of teachers tested in this study, and to suggest how this information might be used to practical effect.

DISCUSSION AND CONCLUSIONS

Certain of the cognitive processes referred to in the presentation of the results of this study concerned the contents of the long term or intermediate term memory stores, others concerned the visual stimulation of the short term memory. The contents of the long term memory refer to what has been learnt and stored in the permanent memory of the individual. If the particular meaning, association, or algorithm necessary for the solution of the problem facing the person is not in the memory store, either because it has never been learnt, or because it has been inadequately learnt and is therefore not readily available, it cannot be used to solve problems, and the person lacking it performs inadequately. For instance, if rules of logic have not been learnt, or if the concept of a square root and the procedure to be followed to compute it have not been learnt, the person with those lacks generally cannot solve problems which include them. This approach to the understanding of mental ability clearly has much to offer in any attempts to present a system of instruction that aims to build on what the learner is supposed to know already.

But there is more to be noticed. The visual stimulation of the short term memory to undertake a search or to follow a line or a path in a limited time, implies that the person will attend to

the stimuli, adopt an appropriate strategy, and consider time important. If for whatever reason the individual has not learnt to do these things, his performance on a task which requires them will show it. Improvement in his performance will obviously depend upon the overcoming of these deficiencies.

The fact that the two samples of teachers in this study differed significantly on age and certain age-related variables, and that these differences were related to performance on at least two of the tests, suggested that it might be valuable to investigate whether the subjects in the sample could be sorted into identifiable subsamples or clusters which differed in their performance on the set of 19 tests. If this could be done it might be a way of discovering which subjects suffered from which deficits in their memory stores as a result of poor or ineffective teaching or learning. If they could be identified, it might then be possible to apply specific remedial teaching where it was particularly needed.

The NIPR computer programme for clustering by reassignment of objects (Muller and Burgers, 1974) was used first to cluster the data of the combined samples in terms of their performances on the 19 tests, and then to identify those clusters in terms of the biographical data on which clusters differed significantly.

The six-cluster solution obtained from the programme provided a useful analysis of the performances of the total sample of 285 subjects on the 19 tests. The solution is given in Table 9. The number of subjects placed in each cluster by the programme is indicated under N, and under the heads of the 5 test groups of reasoning ability, spatial ability, number ability, perceptual speed, and language achievement, are given the mean standardized scores of

Table 9

Mean standardized test group scores and grand mean standardized score for each cluster of subjects on the 5 groups of tests

Cluster	N[+]	Test Groups					Cluster[++] Test Score
		Reasoning	Space	Number	Speed	Language	
1	41	-0,8999	-0,4738	-1,0249	-0,5556	-0,9746	-0,7858
2	59	1,0484	0,9284	0,7080	0,8238	0,6311	0,8279
3	33	0,4264	-0,2452	-0,3638	-0,1706	0,5052	0,0304
4	67	-0,6694	-0,4909	0,1304	-0,6353	-0,4073	-0,4154
5	42	-0,0393	0,5249	-0,5091	0,5405	-0,0794	0,0878
6	43	0,1737	-0,1653	0,8538	-0,0076	0,1270	0,1963

[+] Total N = 285 from samples 1 and 2 combined.

[++] Grand means of the test group means for each cluster.

the test group for each cluster. In the extreme right-hand column of the table is given the grand mean of the test group means. For convenience these grand means are called cluster scores, and they too are standardized for ready comparison.

By comparing the clusters on their cluster scores, it is possible to see the relative standing of the clusters on all of the tests. From the comparison it is evident that in cluster 1 are those subjects who did poorly on all of the tests. In cluster 2, by contrast, are those who did well on all of the tests. Clusters 6 and 5, in that order, rank next in performance. Cluster 3 follows them, and it in turn is followed by cluster 4, which is next to cluster 1 in poor performance.

A look within the table at the various test group scores indicates that the clusters vary in rank of performance on them. For instance, although cluster 2 has the best performance over all of the test groups, cluster 6 excells it in performance on the number test group. Again, although cluster 3 is hardly above average in general performance on the tests, it is next to cluster 2 in high performance on the reasoning and language test groups. Cluster 5, similarly, includes subjects whose performance on the space and speed test groups is second only to the high performance of cluster 2.

This analysis indicates that it has been possible to partition the total sample into subsamples of those who do poorly on all the test groups, those who do well on all the test groups, and those who do well only on certain test groups or combinations of them. By implication this permits the identification of clusters of subjects who perform less well than others on the test groups. It also permits the identification of those clusters of subjects whose

performance is so poor as to suggest that there are learning deficits in their educational histories.

The biographical variables on which the clusters differ significantly are given in Table 10. The chi-squares, the degrees of freedom, and the probabilities of obtaining such patterns by chance are given at the foot of each column. In that Table, the first three columns contain the cluster number, the number of subjects within the cluster, and the cluster test score. The columns which follow include the mean ages of the subjects in the clusters, the percentage of males in each cluster, the mean highest Standard attained at school by each cluster, the percentage in each cluster who were office bearers in organizations outside school, the year teacher training was started, the year teaching was started, the number of years of teaching experience gained, and the percentage of category 1 diplomas obtained in a cluster.

Certain of the biographical variables are age-linked and thus reflect the consequence of being born and of living at a particular period in time with all that that implies for the type of education received as well as the opportunities available for personal development. It is interesting to note, for instance, that the cluster of subjects which performed best on all of the tests, namely cluster 2, also has the lowest mean age, the highest proportion of males in its composition, achieved the highest mean Standard at school, and had the highest proportion of category 1 diploma holders. That there is some relationship among these variables is suggested further by the information on cluster 1, which performed most poorly on all of the tests. That cluster is among those with the highest mean age and the lowest percentage of males in its composition. It has the lowest

Table 10

Cluster test scores from 19 tests and

the values of 8 biographical variables on which the clusters differ significantly

Cluster	N[+]	Cluster[++] Test Score	Mean Age	Sex: % Males	Mean Top Standard	% Office Bearers	Year Started Teacher Training	Year Started Teaching	Years of Teaching Experience	% Category 1 Diplomas
1	41	-0,7858	38	12	7,13	39	59	64	14	15
2	59	0,8279	30	37	8,05	41	67	69	8	95
3	33	0,0304	32	27	7,97	30	67	68	9	87
4	67	-0,4145	38	15	7,54	30	58	54	15	42
5	42	0,0875	33	12	7,84	21	65	67	11	79
6	43	0,1963	34	12	7,82	56	57	61	17	67
Clusters differ significantly on variable at:		X^2 =	279,000	18,978	93,321	13,686	350,102	267,226	294,253	208,739
		df =	224	5	23	5	227	205	226	62
		p =	0,007	0,002	0,0001	0,02	0,0001	0,002	0,001	0,0001

[+] Total N = 285 from samples 1 and 2 combined.

[++] Cluster test score is an index of the relative performance of the cluster on the 19 selected tests.

mean Standard achieved at school, and the lowest proportion of category 1 diploma holders.

A measure of the relationship among the cluster test scores and the 8 biographical variables which differ significantly across clusters is given in the intercorrelation matrix in Table 11. In that table, age, the top school Standard achieved, and category 1 diplomas, are significantly related to the performance of the clusters on the tests, and corroborate what was noticed previously, though it does narrow the focus of the highly correlated variables to three, namely, age, school standard attained, and the holding of a category 1 diploma. If account is also taken of the fact that low age and high proportion of males in a cluster are related, all the other significant correlations can be understood on the basis of the relationships of these four variables.

At this point in the analysis it has been established that it is possible not only to sort the total sample of teachers into subsamples according to their performance on the set of tests administered, but also to indicate the biographical details which make one subsample different from another. It might seem that the next step would be simply to provide cut-off points for performance on a test battery, on age, on school Standard attained, on type of diploma obtained, and on the sex of the individual to be able to decide which teacher enrolled in a course of instruction is likely to require a specific type of remedial teaching to improve his ability to master the course successfully. But the matter is not as simple as that. For instance, on the important variable of age, it is well to bear in mind that the mean ages of the clusters that appear in Table 10 imply a range of ages about the mean. The relatively small number

Table 11

Intercorrelations[+] of cluster test scores and 8 variables on which clusters differ significantly

		1	2	3	4	5	6	7	8	9
Cluster Test Score	1	1.00								
Age	2	-92*	1.00							
Sex/% Males	3	70	-73*	1.00						
Top Standard Mean	4	91*	-91*	63	1.00					
% Office Bearers	5	20	03	02	02	1.00				
Teacher Training Start	6	59	-81*	74*	66	48	1.00			
Started Teaching	7	52	-77*	58	47	13	83*	1.00		
Years Teaching Experience	8	54	74*	-80*	-57	-47	-98*	-79*	1.00	
% Category 1 Diploma	9	91*	-95*	66	99*	09	76*	59	-66	1.00

[+] Decimal points omitted

* Significant at p = 0,05

of years separating the mean ages of the clusters suggests quite correctly that the age ranges of the clusters overlap to a considerable extent and make identification of the individual by means of age as hazardous as would be the attempt to identify him on any of the other variables. Means and percentages have permitted the identification of clusters of subjects, but they are not suitable for decisions about an individual from a new sample of teachers.

And even if it were considered that they were suitable, it is hardly likely that graded instructional courses would be provided to help overcome the various learning deficits from which different subjects might suffer. A more practical approach is likely to be to make improvements in the course material that would help those with whatever learning deficits they possessed to overcome them as much as possible. Such an approach would be designed to reinforce past learning that was already adequate, and to attempt to make up inadequacies wherever these occurred.

The present study may thus be viewed as having assessed the input competencies of those who enrol for the courses offered by SACHED, and to have found that any sample of black teachers will vary considerably in the adequacy with which the educational and personal histories of its members have prepared them for mastery of further study courses. The findings show that it is likely that 65% of those who enrol will suffer from one or other learning deficit which could probably be helped by improvements in the presentation of the course material. And if the improvements in the course material are comprehensive and thorough, even the 14% of participants who are likely to suffer from gross educational deficits could be helped to match mastery of the course with the

motivation which led them to enrol in the first place.

In the evaluation of any instructional system it is important to know the input competencies of those who are to be instructed so that they will benefit as much as possible from the instructions. But although it is important to know what capacities the learners bring with them to the mastery of the course material, it is equally important to know whether the course material is achieving what the instructional system was intended to achieve. The results of the end of the year examinations will, in a sense, give that information, but by that time it is usually too late to help the individual. That kind of information will also not be much use in indicating precisely where the course material failed to help the learner. Criterion tests must be constructed for the purpose of measuring the success of the instructional system (Banathy, 1968). These can be used to evaluate the entire system and to provide feedback for the improvement of the functioning of the components and the processes of the system in the achievement of its objectives.

The achievement tests proposed by the NIPR for the evaluation of the course material offered by SACHED are the criterion tests for each course of instruction, and if developed by SACHED in the light of the information afforded by this study, and as suggested by the NIPR, they will make improvements in the course materials and evaluation of the success of the instructional programme a self-improving enterprise. The importance of helping teachers make up their own educational deficiencies is great enough on its own, but it gains immeasurably from the realization that such help will benefit not only the individual teacher but also the generations of children who, in being taught by teachers whose educational

deficiencies have been remedied, will receive a more adequate education themselves than is possible now. The value of this for the future of the people of South Africa requires no emphasis.

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