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ABSTRACT

This document is a collection of three papers originally prepared as part of a series of public lectures presented by the Faculty of Education at the University of Rhodesia. Each paper stresses the vital need to examine assumptions made about the pupil in school to see whether provisions made for him are really in accordance with his present and future needs. Titles of the three papers are: "The Early Years: The Vital Years of Childhood," "Sex Bias as a Variable in Primary Education," and "Sex Differences in Scientific and Mathematical Competence at Adolescence." (Author/JMB)

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Differences as Factors affectin
Educational Progres

S. F. W. ORBELL, D. J. FREER an
E. HENDRIK

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PRE-SCHOOL OPPORTUNITY AND SEX DIFFERENCES AS FACTORS AFFECTING EDUCATIONAL PROGRESS

Series in Education

Occasional Paper No. 2

by

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FOREWORD

The papers reproduced here were originally prepared as part of a series of six public lectures presented by the Faculty of Education early in 1973.

Once the series was completed it became apparent that the papers which follow were even more closely linked than was originally intended, in that they all attempted to focus attention on some educational base lines. The main purpose of each paper was to stress the fact that there is a vital need to look realistically at some of the assumptions made about the pupil in school to see whether what is provided for him is really in accordance with his needs, both present and future.

The chosen assumptions vary slightly from paper to paper but the conclusions reached by all three of the contributors may be summarised as follows:

> The child in school is much more, and much less, than he appears to be. It is necessary to investigate the real pupil and his circumstances, past and present, in order to be able to make effective educational provision. Such investigation must be as rigorously empirical as possible so that broad principles as well as specific difficulties may be identified. But it will be necessary sometimes to take action even before all the evidence is in, if future educational and developmental problems are to be minimised.

It is hoped, then, that this publication, while pointing, perhaps rather diffidently, at some possible answers in limited, even specialised, fields, will encourage more people to look at the educational processes, both formal and informal, and at the validity of the assumptions on which they are based in the light of present and future empirical findings.

ELIZABETH HENDRIKZ

THE EARLY YEARS: THE VITAL YEARS OF CHILDHOOD

S. F. W. Orbell

In newly independent countries in Africa, the role of education is seen as being so vital for an early participation in the hoped-for riches of modern, scientific societies that some of these countries nearly bankrupt themselves in spending disproportionately large sums of money on education. "Education it is which is all that is lacking, and if we give more people more education, our major problems in this direction will be solved" seems to be a key to the thinking of many political leaders.

They then set about trying to make greatly increased material provision, with disappointing results in that there is little apparent progress following attempts to narrow the gap between the successful ones and the masses. It is interesting to note that, in Western nations, many research findings locate the bulk of the less successful children in the lower working classes, while from the U.S.A. comes strong evidence of negro groups having apparent mean I.Q.s some 15 points lower than those of Caucasian groups.

This is not the occasion critically to review either the research, or the appropriateness of the testing instruments. However, it is suggested that these observations cause understandable concern, particularly in the older educational systems where one sees so much change in educational practice that turns out to be ameliorative rather than curative. For instance, there has been fairly widespread abandonment of selection procedures such as the well-known 11+, as well as of streaming and banding. Then there has been the introduction of comprehensive secondary schools in some countries and, at the other end of the educational process, the mounting of extensive pre-school schemes. One has also read reports of commissions, such as that of the Coleman Commission (1966) which considered whether the quality of the individual school is the major culprit.

Alas, the solution seems to be ever elusive, and one is constrained to ask whether education has in fact only little to contribute to the big leap forward.

But, is this the right question to ask? Until very recently we have not seriously considered whether the major problem lies in the *living material* that the school has to build on. Quite mistakenly, the only real concern has been for *school* education, a concern one can appreciate, particularly in Africa where such pre-school education as there has been, was largely in a manner completely divergent from that which the school gives.

As Skeels (1970) observes with regard to British lower-working-class children (no longer limited to Caucasian stock), the majority of such children who do not succeed at school are probably "born with sound biological constitutions and potentialities for development within the normal range", and yet they may not become contributing members of society because the home has not prepared them for school. Wiseman

(1973) puts it even better. "The effect of environment begins at the moment of birth — and maybe earlier — so that by the time the child arrives at the gates of the school he may already be heavily handicapped."

So firmly held is this view among paediatricians and educational psychologists specialising in child development, that the editor of the *Times Educational Supplement* of 16 February, 1973, headlined an article "Parenthood — too serious to be left to novices". If the claim that the early years are crucial for subsequent development has any validity, one of the first tasks would be to encourage parents to appreciate the vital rôle they have to play in the cognitive development of their children. Novices they would still remain: but as well-informed novices their contribution could result in most significant gains.

Any country's educational policy is probably based on three-major aims, which might be summarised as, firstly, to give all unimpaired children a fair chance, secondly, to minimise drop-outs, and thirdly, and probably most importantly, to maximise intellectual growth over a wider spectrum. With such aims one can only agree, for they are laudable, practical and realisable, but the one common fault in efforts to implement these aims is that too late a start is generally made. It seems timely to examine some of the evidence, before suggesting what might be done.

Bieshenvel (1972), whose extensive writing on African problems has won world-wide acclaim, takes a very clear stand:

> The evidence suggests that for various functions there are critical maturational periods during which physical well-being, mental stimulation (and) environmental inter-action have their optimum effect, and during which future deployment of potential can be permanently affected, either positively or negatively. Inability to take full advantage of later favourable opportunities (for example, in school) would be a consequence.

In short, he is unquestionably accepting the very strong evidence in favour of the critical periods hypothesis, and also implying that failure at school could well result from inadequate and inappropriate action during the early vital years.

There is some doubt about the timing of early critical periods in humans, though they have been generally well mapped for lower forms of animal life. It is probably fairly safe to extrapolate from many of the animal experiments and generalise to human babies. Indeed, as Moray (1959) declares:

> They suggest that the more an animal relies on learning, the more important is a rich, varied environment full of stimuli in the very first weeks and months of life if the brain is to organise itself effectively.

He may be overstating the case for humans, though there is abundant evidence to support the contention that the brain does require stimulation if it is to develop. Suffice it to refer to the work of a brilliant interdisciplinary team made up of a biochemist, an anatomist and two psychologists from the University of California at Berkeley (Bennett, 1964). These four research workers focused their attention on the chemi-

cal and anatomical differences between the brains of rats that lived under conditions of sensory impoverishment and those that experienced sensory enrichment. The enriched ones were found to have:

> heightened levels of a chemical activity that is intimately related to the production of acetylcholine (which is a prime conductor of nerve impulses within the brain). They also have thicker and heavier cortices, and, in general, what is commonly regarded as a better brain.

Turning to another aspect altogether, what is so compelling is the evidence that the patterning of the major stages of intellectual development is invariant across races and cultures, there being no counter claims of any substance. However, it is acknowledged that in different cultures there are considerable differences in the chronological ages at which these stages emerge, and at which they are stabilized.

One of the best reviews of such evidence is that of Werner (1972), who made comparisons of the findings of 40 cross-cultural studies of psychomotor development from birth to two years among contemporary groups of infants on five continents. She found that African infants showed greater motor acceleration than "westernised" urban infants in the first six to twelve months, and a greater decline, after weaning, in adaptive and language development in the second year.

"It is almost as though nature provided a better start where the threat to the security of life is greater. Why, then, are those great advantages so noticeably dissipated well before the child first goes to school? The answers can only be sought in the homes. If one could convince parents that they have a vital rôle to play in the cognitive development of their own children, and if appropriate action were to be taken, it would be interesting to speculate on the extent of the gains that would accrue. Would one see a giant leap forward?

Very rarely has there been such close agreement by two contrasting political parties as is seen in the Conservative and the Labour parties in Britain on the issue of pre-school education, the provision of which is being made a major plank in the pre-election party platforms. With the emergence of play-groups and in the increasing emphasis on the importance of nursery school, a partial answer may be presenting itself. However, intervention and help through these approaches comes only from about age three or four, by which time the battle has, for all practical purposes, been largely won or lost.

It must be admitted that there is some value in both approaches, but both of them, nursery schools more than playgroups, presume that someone else must take on an important parental rôle — but how illogical one is in doing so for only part of the time! Partial answers cannot suffice. There is another illogicality in that, unlike the more sheltered middle-class children, the typical working-class children do not require the playgroup opportunities for the social experience of playing together. Nor are they deficient in most physical skills. When these facts are held constant and we look for common findings among the less successful children, it seems that the problems emerge in the very early stage of language acquisition, the onset of which is as early as eighteen

months of age. This acquisition of language by the child, "though dependent upon maturation of the organism, is essentially a learning process occurring within a matrix of reciprocal communication between adult and child" (Wyatt, 1969). That is to say, without adult mediation, development in this important medium is likely to be markedly poor, as is pointed out by Hawkins (1971) in a recent address to the British Medical Association. He stresses that:

> the common factor in the background of those who are not acquiring confident use of language is lack of access to an adult for long, undisturbed periods before the age of four-and-a-half.

This aspect is graphically illustrated by Luria and Yudovich (1959) who treated a pair of identical young twins that were very retarded in speech, though otherwise normal. Special training in speech was given to the less able twin who, after ten months, excelled in all areas when compared with the originally more able twin who had not received this specialised help. From this and from other experimental work, the Russian psychologists point to the importance of unimpaired speech for adequate mental development. They even go as far as to suggest that the teacher and the specialist can intervene to improve the spoken language and thereby improve the intellectual life of the child.

Another widely supported school of thought emphasising the rôle of language comes from Bernstein (1958) and many workers who have followed his lead. Their view is that there are two culturally-determined kinds of language, termed Restricted and Elaborated Codes, the former being typical of "working class" people. A close link is said to exist between a child's social class background and his success at school, the obvious factor being that of language. Bernstein (1971) explains that "one of the effects of the class system is to limit access to elaborated codes", implying that this richer code might have marked advantage for a child's development.

No defence is needed for this stress on the rôle of language in a child's cognitive development, for it is difficult to imagine the growth of a child's mind to the higher strategies of thinking without the acquisition of this skill. The majority of American theorists are categorical in emphasising that mediation and language are at the heart of reasoning, and though the Geneva school of thought, under the tremendous influence of Piaget, might question this, Piaget (1963) himself concedes the point that "it is hard to conceive how advanced level thinking would develop, or, rather, how it would reach an advanced stage of development without the use of language." His chief co-worker, Inhelder, (1965) goes even further in saying "Language is without doubt the vehicle of choice for thought."

Important as language is, there are other vital factors. Very recently Pollak (1972) published the results of her study of three-year olds in London. She worked with children of chiefly lower-working-class parents from three major groups. English-born, West Indian and "other immigrant groups". There were no differences in birth weights, or in the social class or an income. As she puts it, "These groups lived in the same streets, shopped at the same shops and shared the same pubs".

She found that 87 per cent. of the West Indian children had no toys, 80 per cent. received no birthday presents, and 95 per cent. had no holidays and few outings or treats. Their experience of everyday life was restricted, and their father played little part in their upbringing "but not so the English and other immigrant groups." While motor development at this age was similar in all ways for all three groups, she reports that language development was markedly different, with mean group scores on the tests being:

English-born	12,01
Other immigrant groups	10,77
West Indian	3,35

Furthermore, in measuring adaptability to situations, objects and problem-solving, the mean group score for the English group was 10,32 vs 3,18 for the West Indian Group. She concludes:

> My study in Brixton emphasises the importance of the home in the child's early development and suggests that plans for pre-school education must go hand in hand with making parents a significant part of it. Some parents will need to be taught how to play their rôle of providers of tender loving care and a stimulating environment.

With this viewpoint there would be very little to quarrel about, and though it was made rather graphically 30 years ago by people such as Buhler (1930) one sees depressingly little evidence of the message once home. In this vein, an interesting comment, some 25 years later, comes from Prugle and Bossio (1960) of Birmingham University. Of the eight to 11-year-old maladjusted children whom they studied, nine out of eleven had been separated from their mothers during the first year of life. This is not an attempt to argue that any novice would do provided she is the natural mother, a point which the authors well appreciated in saying:

> Susceptibility to maladjustment and resilience to the shock of separation and deprivation appear to be determined by the quality of human relationships available to the child during critical periods of growth.

This appears to bring one full circle to the opening comments, and it would therefore be timely to draw the threads together. It has been argued that there is ample evidence to support the claim that the pre-school period between ages one-and-a-half and four years is the time when a child is best prepared maximally from the later comprehensive provision which society provides, chiefly through the education system. Writes Beadle (1972):

> The emphasis on correcting failure should shift to the other end of the age scale, with provision for the acquisition of intellectual skills at a time when children can best use the opportunity that is between the ages of two and six.

Apart from the language skills it has also been argued that the regular availability of tender loving care during this period is another vital provision, always accepting, of course, that there is neither neurological nor other physiological impairment. Hawkins *et al.* suggests

so succinctly "the key is in the kitchen" referring clearly to the vital rôle of the mother who is so often unprepared, alone and unaided. To try to meet the worst of the problems attendant upon this, York University has undertaken an interesting experiment which, in part, aims at providing an effective language enrichment programme, chiefly for immigrant children. It is based on the obvious conclusion that there must be the provision of a dialogue with an adult. This is because the adult language, so vital for growth towards the final goal of abstract thinking, cannot be acquired except from an adult. From their work with these immigrant children it is reasonable to expect that there may well result much that will benefit a broader cross-section of children.

At this point it needs to be acknowledged that most of the research evidence cited has been gathered either from lower-working-class situations or from African and Negro studies. This is not a serious danger however and, in this context, the following quotation from Cole and his co-workers (1971) seems apposite.

> In particular, we want to emphasise our major conclusion that cultural differences in cognition reside more in the situations to which particular cognitive processes are applied than in the existence of a process in one cultural group and its absence in another.

There seem to be two major needs. One is the need to mount a vast propaganda campaign, something which the press might undertake as a useful public service. The other, following on from the first, is the need for a large number of suitable volunteer adolescents with regular, sustained access to children on a one-to-one basis. It is submitted that this latter could be most suitable in the local African context. With their marked affection for children, the African people might well find it possible to operate such a scheme with tremendous benefit to both giver and receiver. When all is said and done, there are currently in Africa many youth movements along the lines of Young Pioneers, and similar organisations. How much better to try to win the battle for future men's minds, not in the physical or the political sense but in the cognitive sense. No better investment in the future comes readily to mind.

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SEX BIAS AS A VARIABLE IN PRIMARY EDUCATION

D. J. Freer

Although brief reference will be made to studies across cultures, the main theme of this paper is concerned with differences that appear significant among children from what might reasonably be termed a Western European type of cultural background, as they apply to formal education in primary schools.

Houlton[1] implies that, in Rhodesia, methods in the basic subjects, textbooks in general use and the pattern of teacher education reflect prevailing United Kingdom trends. Atkinson (1973) traces this British influence back to the Report of the Fox Commission (1936).

> Yet at least it made a realistic attempt to bring Southern Rhodesian educational practice closely into line with recent developments in the United Kingdom.

It seems reasonable to assume, therefore, that the organisation of Rhodesian European primary education is similar to British primary education. Such an assumption may not be made about Rhodesian African education. However, evidence is accumulating that suggests, that because of more sophisticated techniques in teaching, young African children no longer display the classroom docility apparent a few years ago. Smith[2] reports on the introduction of a new approach to teaching Grades One and Two and this information is reinforced by the recent introduction of textbooks by Lawton (1972) and Robson (1972) which specify lessons planned along progressive lines. Behavioural patterns and attitudes commonly observed in the European sector may soon be reflected in African primary education.

Implicit in English speaking western primary education is the assumption that boys and girls possess essentially similar skills and attitudes towards learning. Co-educational primary schools are the norm both in U.K. and Rhodesia within the public sector of education. The Department of Education and Science (1967) notes the change in policy in 1926 which gradually leads from a sex segregated policy to an almost total acceptance of co-education in British primary schools. In Rhodesia, the most recent single sex Government primary school dates back to 1932. Conversely within the private sector, segregated primary schools outnumber co-educational ones, indicating perhaps, a parental preference for single sex schools among persons in the higher income groups.

Is government policy in United Kingdom and Rhodesia towards co-education justified? The Department of Education and Science (1967) surveys research that clearly indicates that girls achieve puberty two years earlier than boys and comments that in terms of physical development, implications arise for co-education. In both countries

[1] In Rhodesian Government (1971) Report of Secretary for Education, Salisbury, Government Printer.

[2] In Rhodesian Government (1973) Report of Secretary for African Education, Salisbury, Government Printer.

specific arrangements are made for differences in athletic interests and capabilities. However, in the formal learning situation of the classroom, there is little evidence of allowances made for sex differences. Boys and girls tend to be treated as if intellectual, social and emotional patterns of development are virtually identical. There may be a denial of evolving sex rôles and personality traits in this apparent assumption of sex equality.

At an international level, cross-cultural studies note behavioural differences between the sexes which occur in early childhood. Whiting (1963) reports on observations made in six different societies.

> In each of these societies girls behave in a way that we have called "Domures". A factor analysis of the behaviour shows three things: dominance, nurturance and responsibility, and this combination is essentially the definition of what a mother is to her children. She must be dominant, she nurtures and does the care taking and she is responsible.

He goes on to state that girls exhibit this so-called responsibility at an earlier age than boys. Conversely, in each of the six culture-groups boys are characterized by more physical attack, and more physical aggression than are girls.

In Britain an extensive longitudinal survey has been in progress for several years. Pringle and others (1966) are seeking to:

> explore the constancy and change in the pattern of children's development, longitudinally, and to investigate the associated educational, environmental and physical factors.

The sample of children, chosen in the survey is drawn from all over Britain and is composed of all the children born in one week of March, 1958. Thus every socio-economic group is included. It is interesting to note sex differences that emerge in such a large scale survey. A picture develops in which, both emotionally and intellectually, girls tend to be almost the pace setters in the British educational system up to the age of eight. After their first three months at school at the age of five years, about 25 per cent. of the children are judged by their teachers to be still unsettled. Of these a significantly larger number are boys — something in the ratio of 2:1. It is difficult to be certain of the cause of this but later evidence suggests that girls have a more docile and accepting attitude to school.

The early tendency for girls to exhibit what might be termed "school stability" is supported by evidence that, at a later stage, serious maladjustment occurs far more frequently among boys than among girls. Among the group of 11 000 at the age of seven years, about 13 per cent. of the children indicated some form of maladjustment, as measured on the Bristol Social Adjustment Guide (Stott). Of this 13 per cent., two-thirds were boys. In attempting to establish the cause of this difficulty it is worth noting that many English and American researchers have noted the high incidence of boys compared with girls who are poor readers at this stage. If reading skill is taken as an index of school performance among young children, then it is difficult to establish which is cause and which is effect. Does poor reading ability or slowness in

learning to read lead to a feeling of failure, inadequacy and consequently a tendency to maladjustment? Alternatively, does maladjustment lead to learning difficulties and consequently a poorer school performance? At this stage all that is certain is that a relationship does appear to exist. Which is the causal factor is open to the usual conjecture, though of course at five years of age, the British study indicates a very strong tendency for boys to be more unsettled at school than girls. Does this instability accumulate?

Morris (1966), in a survey of children in primary schools in Kent, finds that girls' reading skill is significantly better than boys' by the age of eight. However, by the age of 11 this dominance has diminished to statistically insignificant proportions. There is a danger here. If long term predictions are made and utilised into some sort of selection procedure in the early years when sex differences in attainment are significant, it may be that a number of boys with high latent ability will be grouped or streamed below their potential. The Department of Education and Science (1967) maintains that homogeneous streaming may penalise boys and supports the contention that there may be a wastage of human talent merely because male children are slower to achieve maturity rather than because of lack of potential ability.

In a limited longitudinal survey of a group of boys and girls in a Rhodesian Primary School during the first five years of their school careers, Freer (1972) suggests that certain trends in cognitive development and school organisation emerge:

(i) Girls as a group are better readers than boys at a similar early age.

(ii) Teachers tend to favour girls in selecting them for "A" stream places, even if intelligence and performance are held constant.

The only comprehensive survey of attainment in Rhodesian primary schools took place in 1952. Dowley (1952) tested the performance of all 10½-11½ year-olds in both the private and public sectors of the non-African educational system. The children were subjected to a battery of intelligence and attainment tests, the following results emerging:

	n	*I.Q. means*	*s.d.*
Boys	1094	98,52	13,8
Girls	1035	99,95	11,95

Girls show a slightly higher I.Q. score of 99,95 over the boys' 98,52 (a difference in means of 1,4). An interesting trend that emerges, is the tendency for the girls to group more closely about the mean than the boys. This replicates a finding of MacMeeker (1939) in Scotland. In Scotland and Rhodesia, girls as a group score slightly higher than the boys, but the former also cluster more closely around a central score. The boys are much more spread out, more having very high and very low scores. This difference in the spread of intelligence scores is also reflected in Mathematics and English attainments, the boys showing a greater spread than the girls in both these areas. However, in Arithmetic the boys' mean is marginally better than the girls'. In English the reverse is true, the girls scoring marginally better than the boys.

This trend for a greater spread of ability in boys, with girls conforming more to a stereotyped pattern, appears to be consistent. Is it due to genetic factors, or is it that the girlish characteristic of conformity and stability in school produces a tendency to group more closely around the mean? Butcher (1968) surveys research in Western Europe and U.S.A., which comes to the conclusion that in primary schools, it is not standards but the atmosphere that sets up some degree of rôle-conflict. Thus it may be that the more docile conformist attitude of women teachers reinforces the desired school behaviour pattern more commonly exhibited by little girls. Male children are of a different mould and this, coupled with the greater success of girls in early intellectual skills such as reading, possibly causes the abilities of boys to be further under-rated and possibly depressed.

Lee (1973) comments on a growing body of research which seeks to examine the effects of feminine dominated attitudes at the lower end of the primary school. Since the time of Froebel, the "mother substitute" has traditionally been the desirable norm in Western European primary schools for children in the age range of five-eight years. Perhaps this should be the subject of investigation and experiment to see if a "father substitute" is not equally necessary and a more acceptable rôle model for little boys. Certainly some challenge to the present practice of only accepting women infant teachers might be investigated.

Butcher (1968) contrasts this briefly with the situation in Japan, where 50 per cent. of primary teachers are men. Interestingly enough, in Japan there is not an imbalance of boys with reading disabilities. Is it due to equivalent male female adult models in the school situation? It may be, of course, peculiar to and as a result of Japanese cultural styles and rôles. However, there are other pointers to culture patterns accentuating differences in performance between the sexes. Anastasi and D'Angelo (1952) find that, in matched samples of five-year-old American white and negro children, differences are reversed in the two cultural groups. Among the white children, girls are significantly better at language skills than the boys. Among the negro group the boys are significantly better than the girls. The researchers conclude that this difference and reversal is probably due to the different rôles played by negro women and girls and white women and girls in their respective societies. Both the Japanese and the American negro conclusions imply that it may be wrong to attribute sex differences in attainment to purely maturational factors. Considerations involving rôle-models of masculine and feminine attitudes to extrovert behaviour may not only affect learning but possibly also produce subjective attitudes towards attainments. In the writer's own limited study a curious tendency emerges. Girls who do not change schools during their primary years have a much greater chance of remaining in or moving to the "A" stream of a three stream school than have boys of similar intelligence who have also spent similar time spans at the same school, or than have children of similar intelligence who enter the school after Standard I. It seems that there is a continuing increment for good behaviour over a period of time for members of the female sex.

Wisenthal (1965) finds that several researchers report male intolerance of uninteresting lessons and a picture emerges of boys refusing to be passively submissive in a basically restrictive classroom situation, expressing what is generally regarded as the typical male characteristic of extroversion. Girls exhibiting a docile acceptance of the classroom situation are rewarded with academic success and approval by their teachers. Wisenthal (*op. cit.*) reviews research in the U.S.A. in which a large sample of teachers show an apparent bias in assigning grades to girls. In the normal classroom situation, girls seem to earn a considerable marking increment for "good behaviour" traits. This marking increment is given both by men and women teachers. A panel of neutral and independent judges who did not know the sexes of the individuals in the group marked the work objectively, as a result of which no significant sex differences in performance emerge.

To summarise, it seems that girls enjoy certain advantages in the early years. The cause of these advantages, particularly in a scholastic skill such as reading, may be due to physiological factors but there is a growing body of information which suggests a cultural and a social influence. Because they are more compliant, girls are easier for teachers to handle and consequently their achievements tend to be perhaps over-valued. It may be that the ethos of infant and lower junior schools is peculiarly feminine and anti-masculine and that this sets up some sort of rôle-conflict producing consequent antagonistic extrovert behaviour in young boys.

It would be wrong to interpret this line of reasoning as a plea for single-sex education. Beyond the primary school there are suggestions that co-education has more advantages than disadvantages. For instance, Dale (1968) finds consistent evidence that boys educated in co-educational schools at the High School level obtain superior attainments to boys educated in single sex schools. He goes on to say:

> There is no evidence whatsoever for the hoary argument that a mixed school is bad for a boy.

He further hypothesises:

> Perhaps friendly rivalry between the sexes and the example set by the greater conscientiousness of the girls more than compensates for distractions and attractions of the opposite sex.

For girls it is found that there is very little difference in performance, whether they are educated at co-educational schools or single-sex ones. From such varied evidence certain tentative recommendations appear justified.

In the early years it seems imperative that teachers should not expect the same behaviour from both sexes and should make allowance for the greater exuberance and slower learning rate of many boys. Possibly if homogeneous ability streaming is utilised in the primary school there is a strong case for equivalent sex streaming, especially as streaming on ability and attainment scores would seem to favour girls as a group. Thus in a typical three-stream school an approach is advocated in which 50 per cent. of the places in each class would be given to boys and 50 per cent. to girls. The existing pattern often produces an "A"

stream with 20 places going to girls and 14 to boys with a consequent reversal of numbers in the "C" stream. A limited educational objective would appear to be to encourage the sexes to learn to live together in harmony by providing for similar numbers in the composition of classes.

Co-education at all levels is relatively new in British-based education. It would be a retrograde step if differences in developmental patterns were used as a basis for a return to single-sex education. What appears to be necessary is comprehensive understanding of the differences between boys and girls in their early years. Separate education for the sexes is not advocated. What is required is a more realistic appraisal of differing behavioural characteristics and rates of development when boys and girls are grouped together in the same classroom.

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SEX DIFFERENCES IN SCIENTIFIC AND MATHEMATICAL COMPETENCE AT ADOLESCENCE

Elizabeth Hendrikz

The principal purpose of this paper is not to identify and explain sex differences in scientific and mathematical competence for their own sake. The real aim is to increase our understanding of some of the factors which appear to be related to the development of such fundamental cognitive abilities as efficient concept formation, spatial reasoning, identifying and testing hypotheses, deduction and induction, etc. It was thought that an examination of the comparative performances, in selected areas, of boys and girls from different educational and cultural backgrounds would enable us not only to identify limiting factors but also to provide pointers to ways of modifying some of the circumstances apparently affecting the development of these sorts of cognitive competence. The specific topic of scientific and mathematical abilities is chiefly a vehicle for this study and not an end in itself. If, as a result, it becomes possible to propose practical ways of overcoming specific problems in this sphere, so much the better, but that must be looked on as a bonus rather than as a major aim.

The title of this paper implies that there are measurable sex differences in scientific and mathematical abilities at adolescence but it does not suggest in which direction the differences lie. There is, in fact, plenty of research evidence that by this stage girls on the whole are inferior to boys in both these areas, though the best of the girls are as good as the best of the boys (see, for example, Maccoby, 1963; Heim, 1970 and McFarlane Smith, 1964). The research confirms the more subjective opinion of high school and university teachers. Confirmation of the existence of such sex differences was also obtained from research undertaken by the writer in Rhodesia (Hendrikz, 1973).

The research was aimed at investigating some of the factors which might have an influence on the development of mathematical and scientific concepts and the logical abilities fundamental to competence in these fields. Everything possible was done to reduce the influence of formal schooling and tests were selected or devised which seemed to measure the more fundamental cognitive skills without which real scientific and mathematical competence are unlikely to be established. For example, two of the group tests sought evidence of the pupils' understanding of such basic concepts as friction, inertia, scientific as opposed to animistic causality, scale and proportion, density, constancy of weight and so on. The questions were designed to give evidence of the level of conceptual development in these spheres rather than of rote or formal learning. As an illustration, the writer sought to distinguish between the mere ability to define density as "weight per unit volume" and the correct use of the concept of density to understand and explain why some common objects float and some sink.

Another group test was aimed at evaluating the pupils' ability to visualise, compare and mentally manipulate shapes in two- and three-

dimensional space. This sort of spatial ability has been widely shown, for example by Vernon (1968) and by McFarlane Smith (*op. cit.*) to correlate significantly with mathematical and scientific competence. In line with this, the research showed that results on test items involving this sort of spatial ability also correlated significantly with competence on the more specifically conceptual tests, which suggests that they are at least related abilities, though the nature of the relationship is not clearly understood. This is not the place to describe all the tests in detail but it is worth mentioning that, in addition to a number of group tests, individual practical problem-solving tests were given to a substantial proportion of the original sample, tests which were aimed at evaluating the sort of scientific logic used in solving the set problems, for example how far trial-and-error was used, or relatively haphazard instead of orderly and progressive hypothesis-testing. The subjects included academic secondary school boys and girls from each of the four major ethnic groups in Rhodesia. They included Form I and Form III pupils from both day and boarding schools, so that it can be seen that a number of cultural, educational and other variables were involved, which formed a useful experimental setting for the original research purpose. In this paper, however, it is intended to limit the discussion to the apparent effects of the sex variable. Below are tables which show a few of the comparative results of the different sexes in only two of the major groups studied. It is worth noting the results cross-culturally, too, but only because they demonstrate that, despite the often obvious sex differences in performance, factors other than sex also enter into the picture. The suggestion arises that differential performance in these tests cannot be solely attributed to biological differences, an important suggestion because of its corollary that, if environmental factors are also influential, they ought to be modifiable if the right procedures are adopted.

TABLE I

Mean raw scores on the Mathematical Insights Test (14+) (N.F.E.R.)
Maximum: 77

GROUP	*FORM I*		*FORM III*	
	N	*mean score*	*N*	*mean score*
European boys	60	55	63	64
European girls	61	55	59	60
African boys	150	49	53	60
African girls	51	51	21	55

TABLE II

Mean raw scores on the Syllogistic Reasoning Test (Hendrikz)
Maximum: 60

GROUP	*FORM I*		*FORM III*	
	N	*mean score*	*N*	*mean score*
European boys	60	31	63	42
European girls	61	28	59	34
African boys	150	23	53	26
African girls	51	21	21	22

TABLE III
Mean raw scores on Science Concepts Test A (Hendrikz)
Maximum: 90

GROUP	FORM I		FORM III	
	N	mean score	N	mean score
European boys	60	61	63	66
European girls	61	48	59	53
African boys	150	44	53	57
African girls	51	34	21	42

TABLE IV
Mean raw scores on Science Concepts Test B (King)
Maximum: 20

GROUP	FORM I		FORM III	
	N	mean score	N	mean score
European boys	60	14	63	17
European girls	61	12	59	14
African boys	150	12	53	13
African girls	51	8	21	11

TABLE V
Mean Percentiles on the Spatial Reasoning Test (Thurstone)

GROUP	FORM I		FORM III	
	N	mean score	N	mean score
European boys	60	49	63	58
European girls	61	41	59	40
African boys	150	27	53	33
African girls	51	18	21	17

The tables demonstrate both a consistent sex difference and a general increase in the gap in performance at the Form III level. The deficit for European girls was relatively less at the Form I than at the Form III level. Notice also that in the Mathematical Insights Test (Table I), which inevitably has a higher formal content, the discrepancies, especially at the Form I level, are negligible. Two interesting facts not visible from the tables are worth mentioning. Firstly, in the European girls' group studied, only 25 per cent. continued with physics-with-chemistry after Form II. The rest had given it up, most of them, according to themselves, because they were "not good at it". The second point to make is that the best of the girls were at least as good on each of the tests as the best of the boys, but the distribution of numbers at the tail end was heavily dominated by girls.

So much then, for some of the evidence from tests designed to assess what may be called a capacity to function competently in the fields of mathematics and science. It does seem that girls at the secondary-school level, looked at as a whole, have a less secure basis than do boys, and the insecurity seems to increase with time, paralleling what has been observed in many educational situations at these ages. The next question to ask ourselves is how far the increasing deficit is biologically

based and how far is it the result of a complexity of factors, both experiential and motivational, which have influenced girls rather than boys. For obvious reasons it is not possible to be dogmatic about the extent to which psycho-sexual differentiation in these sorts of cognitive functioning is genetically determined. Certainly the sex discrepancy in such important things as spatial reasoning, convincingly shown to be an essential for the sorts of mental activity with which we are concerned, is a widespread phenomenon. Heim (*op. cit.*) includes a chapter, entitled the "Mediocrity of Women", in which she argues for a significant biological foundation to sex differences in abilities. A very good survey of the theoretical position to date is Hutt's *Males and Females* (1972). She discusses, among other things, the theory that the Y chromosome, which determines the development of a fertilised ovum into a boy, has the effect first of all of speeding up cell division, resulting in the formation of otherwise neutral cells into embryonic male organs. For the first six weeks after fertilisation both sexes develop in the same manner. If the male testis fails to develop at that stage because it has received no instruction from the Y chromosome, then the same neutral cells will develop two weeks later into ovaries and the foetus becomes female. Probably as a secondary result of the different hormones produced by the sex organs, further physiological differentation takes place, including eventually, some structural differentation in parts of the brain, especially the hypothalamus. After the early speedy development of maleness, the general developmental process in boys slows down, girls maturing physiologically, emotionally and possibly mentally quicker than do boys. Hutt argues that, because of the longer immaturity (and hence potential plasticity) of boys, many sex differences, including emotional and intellectual ones, are biologically based though not necessarily directly genetically determined.

So far all this does not appear to have direct relevance for the scientific and mathematical abilities with which we are concerned, though McFarlane Smith (*op cit.*), in contrast to Vernon (*op. cit.*), Skemp (1970), and others, holds that spatial ability is innate and hence states that the differences are inborn and not acquired. There is one piece of genetic evidence for this which cannot be overlooked. There is a rare genetic abnormality called Turner's syndrome, in which the individual receives at conception only one X chromosome, instead of the normal X + X which makes a female or X + Y which makes a male. Such an individual, because it does not have the Y instruction to develop male characteristics, becomes clearly female, though immaturely so, and is normally brought up as a girl. Although shortish of stature, her intelligence is by most standards perfectly normal and her behaviour feminine, perhaps even "ultra-feminine". But there is a noticeable cognitive deficiency in her poorly developed spatial ability, reflected in problems with mathematical and scientific reasoning. So it looks as though, both from its universality and from the little direct evidence that we have, that there could be a biological basis to sex differences in mathematical and scientific ability. One must remember, of course, that the overlap between the sexes is extensive, many girls being highly

competent and many boys highly incompetent.

Before we finally accept or reject the primacy of biology in this field we must look at the evidence related to non-biological factors which also seems convincingly significant. For example, Maccoby (*op. cit.*) quotes research which demonstrates a relationship between the way an individual has been brought up and his or her competence at mathematics and science. Girls who have been brought up to be independent and to solve their own problems tend to be better at mathematics and science than do others and, conversely, boys brought up to be dependent, especially on their mothers, and who have been overprotected, tend to be linguistically well-developed but mathematically poor. Girls who identify with their fathers rather than their mothers, who are tomboys and who reject authority, tend to be scientifically and mathematically more competent than others. In fact there is a correlation for both boys and girls between their position on a masculinity/feminity scale and their bias towards linguistic or scientific ability. But all this evidence still does not exclude a biologically sex-linked basis to these abilities, since individual differences in the secretion of male and female hormones may well be genetically determined and hence a determinant of cognitive abilities.

The foregoing, however, does not complete the evidence. In the 1950's and the subsequent decade Witkin (1962), Wober (1967) and others studied different modes of intellectual functioning in many different culture-groups. Witkin developed ways of measuring whether an individual habitually sees and analyses problems in their global context or whether he tends to observe and analyse the details instead. He argued that there is a consistency of approach in most individuals, though a continuum exists from very global to very atomistic. He named two categories, "field-dependence" for those not concerned with details but with the total situation (including emotional and aesthetic aspects) and "field-independence" for those who ignore the apparent irrelevancies of context and concentrate on analysing internal facts and relationships. Basically the subject is shown a simple geometric figure on a card and then, after the removal of the first card, is shown a complex figure which includes the simple one within it. The time taken to identify the embedded figures is one of the measures of field-dependence or -independence. There is a strong spatial element in this, and indeed results are significantly correlated with those on other spatial tests, including those which in turn relate to mathematical and scientific aptitude. Witkin used other tests to re-inforce the results of the embedded figures test and found an interesting consistency of approach in most people measured.

Witkin's overall results showed women on the average to be less able than men to disregard the visual field in which the figure is embedded, though there is, again, substantial overlap between the sexes. Other aspects of his investigations showed that "analytic" mothers tend to produce independence in problem solving in their children of both sexes and hence field independence, spatial ability and scientific and mathematical competence. Dawson (1967) and others, using Witkin's tests, found a significant ethnic (or rather, cultural) correlation with

field dependence and independence in groups of people, both men and women, in West Africa. For example, those who had been brought up in a conformist and authoritarian rather than an independent and analytic manner, tended to be field dependent. Similar groups of people were discovered by Beard (1968), Vernon (*op. cit.*), and others to be relatively poor at spatial tests and also at scientific and mathematical reasoning, though the sex discrepancies still existed. There could still be a genetic causality even here, perhaps this time ethnically linked, though an increasing amount of evidence militates against this latter because of the close relationship between traditional child-rearing and educational processes and spatial ability, even within the same ethnic group. A final piece of evidence comes from McArthur (1967) replicating work by Berry (1966) who discovered groups of western Eskimos in which, at least till puberty, there was virtually no difference in the upbringing of boys and girls in their games, toys, dress, responsibilities, etc. While individual differences in spatial ability, field-dependence and independence existed within such groups, they were not dichotomised on sex lines.

The story, then, is not as clear-cut as one would like. The safest thing is to conclude that, while biological and genetic influences probably contribute to sex differences in field-dependence and independence and spatial ability, both of which are widely accepted to be basic to mathematical and scientific competence, it seems as though environmental influences are also important, especially those which determine habitual approaches to the analysis and solution of logical problems, perception of relationships and so on.

It seems appropriate to bring this particular line of reasoning together by coming back again to the measures of spatial ability derived from the local research (Table V). Both sex and ethnic differences were noted, with a different pattern for boys and girls, both African and European. The scores given are in the form of percentiles, which give a placing for each individual in relation to a large group of testees, age differences have been taken into account so that one is able to make a direct comparison between Form I and Form III results. One can see that the sex and ethnic differences are substantial, in both Forms Europeans scored more than the Africans and boys more than girls. The test used was one developed by the Thurstones (1947, 1958), on the theoretical assumption that spatial ability is inborn and not influenced by experience, an assumption, you will remember, which was also made by McFarlane Smith (*op. cit.*) author of the classic work on the subject of spatial ability. If that assumption is justified, the Form III pupils ought to score much the same as they did at Form I. The percentile norms from which the figures were derived are now over twenty years old and were established for Western European children, not for people from different ethnic groups in Rhodesia in the 1970's. However, they still have value, especially when one looks at the comparative figures for Forms I and III. In both boys' groups the Form III score is significantly higher than the Form I score, ($p = < .05$), but in both girls' groups there is a very close relationship indeed.

Interpretation of these scores has, it seems, relevance in helping us

to decide the extent to which spatial ability is modifiable. For European boys, and to a less but still significant extent for African boys, the years between Forms I and III are physically active years in this country, with much more opportunity to explore their environment and a vastly increased opportunity now than 20 years ago for investigating all sorts of mechanical gadgets, old motor cars, electrical implements and so on. Much of this activity involves manipulating spatial and practical rather than verbal relationships, and hence, if one can accept an environmental contribution to spatial ability, it seems only logical that an increment in experience in the adolescent years should show on a good test of spatial ability. The superior performance of European boys over African boys can be accounted for environmentally if one compares the traditional early upbringing of boys in a European culture with that of boys in an African culture. Different travel opportunities, toys, attitudes to authority, different traditional beliefs about the physical world and many other factors could well contribute to the difference. We are not really getting away from the theme of this paper since it seems at least possible that sex differences in spatial ability may to some extent be brought about by some of the same sorts of influences at work cross-culturally. The girls' scores shown on Table V stay almost identical but, if one considers the differing interests of boys and girls at this age, it seems a predictable result for most of them, since if anything girls, at least in this country, are rather less active at this age than earlier in practical, mechanical and even independent geographical movement. Nothing extra has been added to their lives to stimulate an increase in spatial ability. Similarly the sex discrepancy *vis-à-vis* their male counterparts, genetics aside, can also be accounted for at least partially in long-term experiential ways, in which right from the early weeks of life girls are usually (unless they happen to be western Eskimos) treated differently from boys, especially in spheres related to spatial, exploratory, practical and mechanical activities. African girls usually lead a much more circumscribed existence than do their brothers and this could be reflected in their much lower scores.

An aspect worth looking at in addition to the directly experiential one is that of self-expectation, and hence motivation. The general and specific culture in which one is brought up builds up over the years a picture of what is appropriate and what inappropriate, what is masculine and what feminine behaviour and so on. All teachers know that children tend to produce, within obvious limits, what is expected of them and what they expect of themselves, both of which concepts they develop over the years. It is possible that many girls have been "brainwashed" into believing that mathematics and science are not their province. As a result, even when they have not been environmentally handicapped in the development of the spatial and other abilities basic to scientific competence, they still may not achieve what they are potentially capable of because of motivational limitations. Perhaps the fact that only 25 per cent. of the European girls studied continued with the physical sciences after Form II is a reflection of this. In addition, many of them, when asked what "O-level" science subject they were taking, said "None",

until they were reminded that biology is a science!

There is plenty more empirical evidence to support the cultural, experimental and motivational contributions to scientific and mathematical abilities but enough has been given for our purposes. A few interesting pointers about local conditions were found in which, for example, African boarding school girls, whose lives are much less circumscribed than those of day-school girls, scored fractionally better on spatial and conceptual tests than did the latter. African day-school boys, on the other hand, were slightly better than their boarding-school counterparts, which may reflect the wider urban out-of-school environmental experiences such boys have.

To summarise, we have seen evidence that, in several abilities related to mathematical and scientific competence, girls are widely found to be inferior to boys, though the overlap is extensive, the best of the girls being as good as the best of the boys. Because of the widespread existence of the discrepancy and from the as yet limited direct evidence, one may safely conclude that there is a biological, both genetic and hormonal, contribution to the discrepancy. However, we have also examined evidence which suggests that this is not the whole of the picture, because even within an ethnic group there are variations in the pattern which coincide with general cultural norms and expectations and specific upbringing patterns and experiences. Discrepancies, at least locally, appear to increase in early and mid-adolescence, when motivation and cultural expectations are becoming defined and also more sexually differentiated, providing further evidence of the potential modifiability of the basic abilities. It does seem as though, genetics apart, it should be possible so to arrange the school, if not the home environment to modify some of the limiting factors and enable girls as well as boys to become scientifically and mathematically more competent than many of them presently are.

It could be argued that there is no ethical or moral justification for planning for such a modification. This is not an argument to go into here in any depth, except perhaps to say that, while not necessarily wanting to produce large numbers of scientific and mathematical specialists among women, there is at present a lot of wasted talent which will become increasingly valuable in an increasingly technological world. If scientifically-minded people could be produced, both men and women, who had some of the holistic and human perspective of the field-dependents as well as the analytic insight of the field-independents, the world might be a pleasanter and safer place. Modification of factors limiting the development of the abilities which we have been examining involves the home and pre-school educational opportunities as well as approaches in the formal school. A great deal more research will be necessary before one can be sure which methods will most effectively and economically achieve the purpose. But at least a start has been made in unravelling some of the mysteries of the interaction of genetics and environment in the development of human abilities.

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