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SEX-DIFFERENCES IN MATHEMATICS IN THE EARLY YEARS OF SECONDARY SCHOOLING.

BY

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ABSTRACT

The object of this enquiry is to investigate how sex differences in mathematics develop in the early years of secondary schooling, and to try and identify specific areas of mathematics in which one sex out-performs the other for this age group.

As a background to the enquiry the biological bases for differences between the sexes are considered and some well-established psychological sex differences are mentioned, along with some commonly held misconceptions about sex differences.

An examination of previous research into mathematical sex differences reveals that before the age of eleven there is little difference between the sexes. However, from this age upwards boys' ability in mathematics develops more rapidly than girls'. The cause of this is a complex interaction of biological, personal and social factors in which education plays a very important part.

The subjects of the enquiry were a complete first year in an eleven to fourteen high school, who were given standardised mathematics and English attainment tests on entry to the school. In order to measure their mathematical development the subjects were tested again a year later using a similar mathematics test.

A comparison of the two mathematics tests shows that the boys achieve higher average marks than the girls and that the difference is larger for the second test. However, neither difference is sufficiently large to be significant. The boys' marks were significantly more variable than the girls' and the correlation between the two tests was higher for the boys indicating that the boys performance is more consistent over

the period of the enquiry. A comparison of the mathematics tests with the English test shows higher correlations for the girls than boys which implies that girls who are good at mathematics are more likely to be good at English than boys or vice versa. A breakdown of the two mathematics tests into specific areas reveals that the boys are more capable of answering questions involving fractions, comparisons and measurement than girls. If this applies to all children, then in order to achieve equality between the sexes in mathematical ability, a different emphasis in the teaching of these areas will have to be sought.

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INTRODUCTION

According to the Equal Opportunities Commission (c 1980) the Sex Discrimination Act of 1975 makes sex discrimination unlawful in education. Yet one reads regularly articles in the press bemoaning the lack of female mathematicians and scientists (see Kelly (1981)). Careers are obviously affected by subject choices in schools and a glance at the ordinary and advanced level G.C.E. results in Figure (i) shows why females are so poorly represented in these fields. However,

Subject and level	Males	Females
Mathematics 'A'	76.0	24.0
Mathematics 'O'	61.7	38.3
Physics 'A'	81.1	18.9
Physics 'O'	75.5	24.4
Chemistry 'A'	69.1	30.9
Chemistry 'O'	64.2	35.8
Biology 'A'	46.3	53.7
Biology 'O'	40.2	59.8
French 'A'	35.9	64.1
French 'O'	40.2	59.8
English Language 'O'	42.6	57.4
English Literature 'A'	44.8	55.2
All 'O' levels	49.5	50.5
All 'A' levels	56.5	43.5

Figure (i): Percentage passes by sex out of all passes in selected subjects at 'O' and 'A' level - Summer 1979.

(Source: D.E.S. Statistics of Education Volume 2

School leavers C.S.E. and G.C.E. 1979, Tables 31 and 32) a more general view of the results shows that there is little reason to conclude that girls are less intelligent than boys. It is apparent though, that differences in the cognitive abilities do exist. Are these differences inbuilt into boys and girls or do they occur as part of the process of growing up? If schooling is responsible, do boys and girls respond differently to the same treatment or are boys and girls treated differently in school? The D.E.S. (1975) itself states that there is evidence to show that there are some differences in the curriculum that "militate against the personal development or the career prospects of girls". As will be shown in the first two chapters there are no simple answers to these two questions but clearly if boys and girls are being treated differently then the law is being broken. There is one school of thought which says that education should allow each sex to develop in its own way and thus emphasise any differences between the sexes that are inbuilt. Contrary to this are those who feel that to let sex differences develop in this way severely disadvantages females competing for equal rights in what has, up to very recently, been a predominantly male world.

Biggs (1967) has shown that boys and girls respond differently to different types of teaching and it may be that if mathematical equality between the sexes is to be achieved then boys and girls may need to be taught with different emphases. Such is the current concern about cognitive sex-differences that there are a number of projects in existance, two atleast of which deal specifically with mathematics. The "Mathematics Education and Girls" project is being sponsored by British Petroleum at Sheffield City Polytechnic and the "Girls and Mathematics" project is being conducted at the University of London Institute of Education. Recently, the "Girls and Mathematics Association" has been formed to look at why girls do badly in mathematics (Times Educational Supplement, (9:10:81)).

Although there has already been a certain amount of research work dealing with sex-differences in mathematics, the list is not extensive and a large proportion of it originates from the United States. Recent studies in the United Kingdom by Preston (1972), Wood (1976) and Sharma (1979) have concentrated on sex-differences in mathematical performance in public examinations. These studies highlight differences in the end product of our educational system. Many writers, for example Hutt (1972), Lynn (1962) and Shuard (1981) feel that sex-differences in mathematics are caused much earlier in life, possibly even in pre-school days. The D.E.S. (1975) indicates that creative play in the early stages of primary school might unintentionally be responsible for later sex-differences in mathematics and science.

Clearly it is necessary to look at each stage of schooling in order to analyse and remedy, if that is what society wants, any sex-bias which might exist. This study examines the previous research in the area of mathematical sex-differences and looks at the mathematical development of a group of boys and girls over a period of a year at the beginning of the secondary school to see whether any differences between the sexes are becoming apparent at this stage.

CHAPTER 1.

BIOLOGICAL AND PSYCHOLOGICAL SEX-DIFFERENCE

1 . 1 The "Nature" v "Nurture" Problem.

According to Hamburg and Lunde (1967) sex-differences in human behaviour are determined by genetic, hormonal and environmental factors. There are those such as Blackstone and Weinrich-Haste (1980) who would argue that the gender role is developed entirely by the learning process. The corresponding parts played by biological and environmental factors in the development of sex-differences has become known in psychological terms as the "nature" versus "nurture" problem (see Biggs (1962) p 130). Whichever stance one adopts it is obvious that education has a very important part to play in the differences which exist between the sexes. In mathematics, teachers try to treat both sexes in the same way (although the Equal Opportunities Commission (c1980) point out that in practice this may not be so) and hope that they will become equally proficient in the subject. Either through biological differences or through differences in the environment this, as will be shown in Chapter 2, does not happen. It will be helpful before examining the mathematical differences which the sexes exhibit to take a more general view at the biological aspects of sex-differences.

1 . 2 Biological Sex-Differences

Every cell of a human being contains forty-six chromosomes, twenty-three of these being from each parent which align themselves in pairs. The twenty-third pair determines the sex of the individual and consists of an XX pair in the female and an XY pair in the male. A mother can only endow her child with an X-chromosome, so it is the father who determines the sex of the child. There are several consequences of the differences in the sex-chromosomal composition of men and women. The male, for example, is more susceptible to a number of recessive disorders and illness in general, so much so that whilst the ratio of male live births to female ones is 106 to 100, by the sixth decade this ratio has been reversed (see Hutt (1972)). Hutt writes that "the adage of the male being the stronger sex seems to be limited very much to physical strength". Ounsted and Taylor (1972) attribute this phenomenon to the characteristics of the Y-chromosome and postulate that it is also responsible for the slower maturation of the male and the greater variability in some male features and functions.

The functions of an animal are regulated by the nervous and endocrine systems. The endocrine system consists of glands or organs which secrete chemical substances, hormones, into the blood stream. Some of these glands, notably the gonads, adrenals and the pituitary behave differently in the two sexes. The gonads, (testes in the male and ovaries in the female) and to a lesser extent the adrenals, are responsible for secreting the hormones (testerone in the male and oestrogens and progesterone in the female) which are responsible for sexual development, but the release of these hormones is under the control of hormones called gonadotrophins from the pituitary gland which in turn is controlled by the hypothalmus of the brain. The female is hormonally more complex than the male with both the pituitary and the gonads producing two or more different types of hormone. More importantly, the hypothalmus functions differently in males and females instructing the gonads to output fairly constant amounts of hormones in males, whilst in the female the gonadal output is cyclic, one consequence of which is the female menstrual cycle.

The sex hormones exert an influence on many non-sexual functions. Testerone, for example, promotes tissue growth, whereas the female hormones control the amount and location of fat deposition. There are a variety of other non-sexual differences between the sexes which can be attributed to genetic or hormonal sex-differences. A selection are listed here. Up to puberty girls mature ahead of boys, crawling, walking and talking earlier, on average. Girls are shorter and lighter from birth to about the age of eight, and their calorie intake is less. Boys, on the other hand, are physically stronger and more aggressive than girls. The sex hormones are also responsible for the characteristic changes in males and females which occur at puberty and these are controlled essentially by the hypothalmus. Since the hypothalmus is such an important control centre Hutt (1972) postulates that "it is unlikely that other non-sexual functions controlled by the hypothalmus remain entirely unaffected by its differentiation according to sex".

1 . 3 Psychological Sex-Differences.

A great deal of research has been carried out in the area of non-sexual differences between the sexes especially in the psychological field and it is one small part of this which is the concern of this thesis. There is one school of thought which argues that all psychological sex-differences are entirely the result of the learning process which is quite independent of any chromosomal or hormonal sex differences. Hampson (1965) writes that "the gender role ..... is differentiated through learning during the course of many experiences of growing up". Implied in this statement is that if boys and girls are treated identically there should be no observable psychological differences between the sexes. However this standpoint has many critics, amongst them Hutt (1972) and Beach (1965) who writes that despite the fact that such a theory cannot be tested it is likely that there are sex differences in the functional characteristics of the male and female brain which are manifest at birth and have some effect on the learning process. Similarly implied in this statement is the fact that if boys and girls are treated identically it is likely that there will be observable differences in some aspects of their mental development. Nevertheless both factions are in agreement that the learning processes have an important part to play in the requisition of psychological sex-differences and gender roles.

Maccoby and Jacklin (1975) give a list of these differences between boys and girls, whether due to conditioning, or biological differences, or, as is more likely, a combination of the two, which have been well established by research.

1. Girls have greater verbal ability than boys, particularly from the age of 11 onwards.
2. Boys excel in visual-spatial ability in adolescence and adulthood, but not in childhood.
3. Boys excel in mathematical ability. Up to the age of twelve or thirteen there is no appreciable difference between the sexes but after that, boys' ability increases more rapidly than that of girls.
4. Males are more aggressive.

The next chapter will be concerned with a review of research looking into the area of sex differences in mathematics to see whether recent research in Britain reinforces the conclusions reached by Maccoby and Jacklin about male mathematical superiority.

It will be found that the majority of research does back them up. In the light of some of the reasons given for male superiority it is worth noting some of the other conclusions reached by Maccoby and Jacklin who made two other lists of sex-differences. The first contains unfounded beliefs about psychological sex-differences and the second contains a list of differences which at the time there was too little evidence to confirm or contradict.

5. Neither sex is more susceptible to rote learning or better at performing tasks that require a lot of thought.
6. Neither sex is more analytic (unless the task involves visual-spatial ability).
7. There is no sex-difference in achievement motivation, although boys and girls are motivated in different ways.
8. There is not enough evidence to determine whether girls are more timid or anxious than boys, although girls and teachers tend to think that this is so.
9. Some studies show boys to be more competitive than girls but there are many studies which find no difference between girls and boys.
10. In childhood, girls tend to be more compliant to the demands of adults but not to other children.

CHAPTER 2

A REVIEW OF PREVIOUS RESEARCH

2 . 1 Sex-Differences in Mathematical Attainment.

In order to make such statements as those listed in the previous chapter, Maccoby and Jacklin (1975) made a thorough review of the literature in which such research was likely to be published between January, 1966 and Spring, 1973. In all they reviewed thirty-five pieces of work relating to sex-differences in mathematics. Of these, fifteen showed no differences between the sexes, four favoured girls and the remainder showed that boys or men achieved higher average scores than females of the same age. It is interesting to note how these differences are distributed over the age range, from 3 to 21 years, covered by these thirty-five surveys. All four of the studies in which the girls came out on top were in the age range three to ten. All sixteen which favoured the males occured in the age range from twelve to twenty-one.

In addition to the above research, Maccoby and Jacklin had available to them a similar collation of studies completed between 1928 and 1965, and summarised in a preceeding volume by Maccoby (1967). Here, of the forty studies dealing with counting, computation and mathematical reasoning, seven favoured girls, twelve favoured boys and men and the remainder showed no difference. All three studies on counting (between the ages of two and six) showed girls to be superior. Of the studies on computation three favoured girls (aged eight and thirteen), one favoured males (from nine to twenty-three years of age) and the remaining thirteen showed no difference. However, in eleven of the twenty studies dealing with mathematical reasoning, boys and men (with an age range from eight to adulthood) came out on top, but on only one test did girls (aged eight) show themselves to be superior.

Since many researchers into sex-differences in mathematics give spatial ability as one of the causes or reasons for mathematical differences it is worth looking at Maccoby (1967) and Maccoby and Jacklin's (1975) summaries of this field. Maccoby reports that in twelve of the eighteen studies reviewed boys were superior in spatial tasks and the rest showed no difference. Maccoby and Jacklin list seventy-seven studies (or ninety-nine if different ages within each study are considered). Of those, thirty-four show men and boys above the age of seven to be superior and five favour girls, all less than ten years of age.

So there is a lot of evidence to support Maccoby and Jacklin's claims about sex differences in mathematical and spatial ability. Most of the research summarised above was American in origin, but recent work in Britain only serves to add weight to their findings.

Pidgeon (1960) found that at 7+ girls were slightly ahead of boys in their scores on a standardised mechanical arithmetic test. By the age of 10+ this difference had increased to three standardised points, and girls of this age were also slightly ahead in problem arithmetic. At 14+ the girls were only slightly ahead in mechanical arithmetic but the boys were almost five points ahead in problem arithmetic "indicating", as Pidgeon wrote, "that there is a distinct falling off in the performance of girls in this subject between the ages of eleven and fourteen". Douglas et al (1968) found that at the age of fifteen boys make higher scores in mathematics tests than girls and this holds across all social classes. Research by Wood (1976) and Sharma and Meighan (1980) shows that boys out-perform girls in 'O' level Mathematics examinations, both in multiple choice and free response types of question. Recent publications by the Assessment of Performance Unit (1980 a, b) show that at the age of eleven girls scored significantly higher marks in computation and boys in length, area, volume and capacity, applications of number, and rate and ratio. In the other nine categories tested there was no significant difference in the scores of boys and girls. However, by the age of fifteen boys had higher mean scores in every sub-category surveyed and in all but four of the fifteen sub-categories (modern algebra, modern geometry, probability and statistics) the differences were significant. Further analysis of the fifteen-year-olds' data shows that the boys' higher mean scores are due to a preponderance of boys in the top performance bands than to a preponderance of girls in the lowest bands.

The comparatively poor performance of girls at the secondary level is not confined to Britain and the United States. In a survey of twelve countries Husen (1967) reports that in forty of the forty-two populations surveyed (aged thirteen or of pre-university age) boys came out on top in overall maths scores, the two exceptions being Israeli third-formers and Australian pre-university maths specialists. The mean sex difference amongst thirteen year olds was highest in Belgium, Japan, the Netherlands and England, and the smallest sex differences throughout were found in the United States and Sweden, although there was very little difference in the scores of male and female pre-university maths specialists in England. Pidgeon (1967), commenting in the English report of the International Survey, puts this down to the very fact that they are specialists and the ratio of males to females in this population was greater than 5 : 1. In a study of sex differences in mathematical attainment in Irish Schools, Nevin (1973) found no difference between boys and girls at primary level, but reported that girls fell behind boys in secondary schools and their leaving certificate results were correspondingly poor.

So, as Pidgeon (1967) writes, "there is very strong evidence that the mathematical performance of boys is superior to that of girls over most of the secondary age range". Indeed there seems to be some justification also for the claims of Walkerdine and Walden (1981) and St. John-Brooks (1981) that up to the age of eleven girls are ahead of boys in arithmetical performances. St.John-Brooks points out that in the days of the 11 plus, tests were standardised by some authorities to be biased against girls so that girls did not end up getting more grammar school places than boys.

If there is a general concensus of opinion by researchers that boys are superior to girls in mathematical attainment at the secondary level, then this is contrasted by the varying explanations given for this difference. These explanations are grouped loosely together in the following subsections.

2 . 2 Factorial Analysis.

Early psychological researchers tried to isolate the various factors involved in different abilities. Spearman (1927) found that the most important factor in all abilities was basic intelligence, which he labelled g. Researchers in the mathematical field tried to isolate a mathematical group factor which was common to all branches of mathematics. Early researchers found that there was not a factor that was common to mathematics. Spearman himself, felt that arithmetic and geometry involved different abilities. Oldham (1938) reported that there was no large group factors evident when arithmetic, algebra and geometry were taken in pairs or all three together and when group factors did exist they were due to extraneous influences such as teaching methods or the application of number to geometry. She could see no reason to justify placing the three branches of mathematics in one class for the purpose of examination.

The research which is of most interest in this field seems to be that of Blackwell (1940). She found that different factors are involved in the mathematical ability of boys and girls. For both sexes she discovered that the most important factor was general intelligence (g). Second in importance was a spatial factor (o), although this plays a greater part in the mathematical ability of boys than of girls. Girls then have a verbal factor, (v), whereas boys have a verbal reasoning factor (w), which makes it easier for boys to follow through the logical steps of an argument. In addition to these, there is evidence that girls possess a fourth factor (x), which is the ability to retain data in an exact form. However, Blackwell was able to find no overall mathematical group factor.

This is contrasted by more recent work by Barakat (1951 a, b) Lee (1955) and Wrigley (1958) who found that a mathematical factor does exist. Wrigley criticises the statistical techniques used by Blackwell and Oldham and says that their findings are actually consistent with the hypothesis of a group factor for mathematical ability even though they claimed the opposite. But he does not question the factorial differences for boys and girls. Barakat (1956) however, finds the same four factors for the mathematical abilities of both boys and girls((i) a general factor g, (ii) a group factor for mathematical ability, (iii) a verbal factor, and (iv) a visuo-spatial factor) , though he does say (1951 a) that he found minor differences between the weighting of the factors obtained for boys and girls.

Blackwell mentions the spatial factor playing a greater part in boys' mathematical ability compared with that of girls. As has been mentioned earlier there is considerable evidence that males excel in spatial ability. The research for this has been well documented by Maccoby (1967) and Maccoby and Jacklin (1975) and leads Fennema (1974) to comment that "the most promising intellectual factor that may partially explain boys' superior mathematics performance is spatial ability". It is not proposed here to review the literature concerning sex differences in spatial abilities but merely to comment, along with Hutt (1974) and Gray (1981) of its apparent existence in favour of boys from early adolescence onwards. Since the work of Blackwell (1940), Barakat (1951 b), Wrigley (1958) and Macfarlane Smith (1964) has shown that a spatial factor plays an important part in mathematical ability, it seems sensible to combine these two sets of findings and say that it is likely that spatial ability has some bearing on the mathematical differences between boys and girls. Of particular note, comments Fennema (1974), is theparallel improvement of boys in spatial and mathematical abilities at roughly the same age, but as St. John-Brooks (1981) points out, the relationship between the two is not really well understood.

With the exception then of spatial abilities, the evidence for the different factorial make-up in the mathematical abilities of boys and girls is scanty, and even if a difference does exist there is no attempt in factorial analysis to explain whether such a difference is genetic or conditioned.

2 . 3 Biological Factors

This is one area in the question of sex-differences in intellectual abilities which is shrouded in mystery and controversy. Opinions range from that of Blackstone and Weinrich-Haste (1980) who state that "sex-differences in cognitive abilities have no biological and physiological base", to those of Benbow and Stanley (1980) who feel that girls are intrinsically less able mathematicians. In fact, as Gray (1981) points out, there is very little research which exists for the simple reason that it is very difficult to set up a control group against which to measure any experiments. Most of the research which does exist is in the area of spatial ability. Stafford (1961) has put forward evidence that aptitude for visualizing space has an hereditary component transmitted by the X-chromosome. He draws his conclusions from correlations of spatial ability between parents and their offspring. However, Gray (1981) comments that recent experiments have failed to confirm these earlier findings and a study by Besch et al (1961) shows that there is unlikely to be a direct biological link between mental and physical growth.

In the mathematical field there is even less material dealing with biological influences on observed sex-differences. In their Study of Mathematically Precocious Youth, Benbow, Stanley (1980) and other researchers at the John Hopkins University found that in the mathematical portion of their Scholastic Aptitude Test, boys scored far higher marks than girls. The greatest differences they recorded was amongst the most brilliant youngsters. They concluded that the differences which they found were too great to be accounted for by socialization alone and therefore genetic differences must play a substantial part. However, they do concede that "our data are consistent with numerous alternative hypotheses". Their findings are in fact criticised by Shaeffer and Gray (1981), who feel that environmental factors such as teaching materials have more effect on the comparative development of boys and girls.

One is left to conclude that the part that biological differences play in the mathematical differences of boys and girls is just not known. Fennema (1974) comments that in any case

> "The argument appears to be an academic one. The number of females who elect not to study mathematics and who achieve at lower levels is much larger than any differences in innate ability would dictate. Therefore other factors must play a deciding role".

Whilst this may be true, it would be helpful to know if such differences did exist, because then it might be possible to correct for them our teaching.

2 . 4 Environmental Contributions

If the previous section was noted for its brevity this will be more than compensated by the research evidence in this area for two reasons. Firstly, it is relatively easy to control an experiment dealing with a specific environmental factor (although it is very difficult to control all the variables that may effect the area under investigation). Secondly, there are a large number of ways in which the environment may affect the learning process of boys and girls, for example, teaching methods, types of schools, sex-stereotyping and the attitudes of boys and girls to learning. Because of the interactions between these areas it is very difficult to put a particular piece of research into a particular category and there will be an inevitable overlap between categories but there follows an attempt to classfiy reasons given by researchers for mathematical sex-differences.

2 . 5 The Effects of Schooling.

Between 1959 and 1961 the N.F.E.R. conducted a survey into the effects of various teaching methods in primary schools on mathematics attainment and attitudes. The author of the report, Biggs (1967), postulated that girls code more narrowly than boys (that is that boys are more able to relate a situation to a similar one which has occured and hence develop a greater depth of understanding, whilst girls are more concerned with the method or task in hand and hence adopt rote-learning techniques). Amongst other things, it was found that boys and girls reacted differently to different teaching methods. Girls obtained higher scores on tests requiring rote rather than insightful learning and were also found to be less number anxious under more formal traditional teaching methods. The experiment consisted of exposing one group of pupils to structural teaching methods (that is those using apparatus such as Diene's Apparatus) and a second group of pupils, the controls, to traditional methods. Structural methods were found to be most successful with highly intelligent boys.

However, it is perhaps more striking that whilst boys made steady progress over the two years the experiment was run, theexperimental girls had, after the first year, much higher anxiety and lower concept scores than the controls. During the second year, though, these girls made extremely good progress, more than making up for the initial decrement. This lead Biggs to conclude that "girls need rather more structural experience than boys if they are to possess an equally sound grasp of mathematics".

In a survey of schools in the East Midlands, Sturgess (c 1972) found that girls schools had adopted more modern texts than had boys schools, but this was explained by the fact that many teachers in boys schools are concerned about thesuitability of modern texts for boys who will follow engineering courses and trade apprenticeships on leaving school.

Jones (1973) reported comparatively few differences between the sexes at the age of 11 in the methods used to solve mathematical problems but he found that those differences which did exist were greater in a more formal teaching situation than in an open one. He concluded that the female personality traits of a desire to conform and to accept the methods presented are increased by a formal and competitive environment. This could stunt girls' progress, and to overcome this they need to be encouraged to look for alternative methods for answering problems. Preston (1972) advises careful consideration of the content and learning experiences offered to secondary school girls. His findings seem to indicate a need for the mathematical experience to be directly related to the environment of the female adolescent.

Other researchers offer the different experiences given to primary school children as the cause of mathematical sex differences in their school careers. Byrne (1978) states that "girls are often discouraged from mathematical work in the primary years. They therefore dislike it in the secondary years". The Equal Opportunities Commission (c 1980) reports that there is an increasing body of evidence to suggest that lack of early activities involving spatial awareness and insufficient experience with mechanical toys and puzzles are important contributory factors in the later under-achievement of girls in mathematics and science. This is also mentioned by the D.E.S. (1975). Shuard (1981) asks the question "Does success come too easily for primary school girls?" and suggests that it may be that the over-emphasis on success in computational skills in the primary school may be counter-productive in the case of girls because it causes under-emphasis on facets of mathematics which become progressively more important in the secondary school.

Perhaps another cause of mathematical sex-differences is the sex of the teacher. The D.E.S. (1975) points out that up to the age of seven, children are taught almost exclusively by women and between the ages of seven and eleven women teachers are predominant. At secondary level the balance is more equal, although there are more men in authority. Weiner (1980) feels that such school organization affects boys and girls in terms of both what they feel able to tackle and also their future career expectations. It is perhaps more than coincidence that girls seem to perform better at an age when the majority of their teachers are female.

Some studies have found that the type of school a child attends may have some bearing on its mathematical performance, although the evidence presented seems somewhat contradictory. In the International Survey (1967), Husen (1967) reports that on the whole sex-differences in scores were much smaller in co-educational schools and this is reiterated by Douglas et al (1968). Preston (1972) found that the attitude towards mathematics of girls who study in co-educational establishments is different from those who study in all-girls schools. (This will be looked at in greater detail in the next section.)

In a recent report for the National Childrens Bureau, Steedman (1980) comments that, whilst there is no overall difference between pupils in mixed and single-sex schools, girls' scores were closer to boys' in single-sex grammar schools than in any other type of school. In fact there was a difference of only one twelfth of a standard deviation in favour of boys. "This", she writes "confirms other research that shows that single-sex grammar schools are the only type of school in which girls at sixteen seem to have an equal chance of scoring highly in mathematics". The D.E.S. (1975) states that more girls in single-sex schools take maths and further maths at 'A' level than in mixed schools. However, the rest of Steedman's findings contradict those of Husen and Douglas because she reports that sex-differences are much the same for co-educational grammar schools and comprehensive schools and single-sex comprehensives. According to Geddes (1981), the Assessment of Performance Unit found that both boys and girls achieved significantly higher scores on the maths tests if they were in any type of single-sex school . This is questioned by Steedman (1981) who says that the A.P.U. made no distinction between single-sex grammar and comprehensive schools, and the performance of girls in grammar schools accounts for all the differences reported by Geddes.

Nevertheless, there are a number of people who feel that boys and girls ought to be taught separately for all or part of the school timetable. Hawes (1981) argues that the sexes ought to be separated for certain subjects, such as sciences. Shaw (1980) on the other hand advocates a return to single-sex schools if girls and boys are to obtain educational equality.

Another factor affecting a pupil's overall mathematics performance could be the different options that are open to pupils in the later years of secondary schooling. Fennema and Sherman (1977) in fact cast doubt upon much of the previous research into mathematical sex-differences because many of these studies have not controlled one very important variable - the previous study of mathematics. In a study unusual for its outcome, Mayer and Bending (1961) reported that scores for verbal meaning, reasoning, word fluency and numeracy were higher for sixteen year old girls than for boys. The reason they gave for this was that the girls had taken part in a commercial studies course which improved their performance in speed and accuracy compared with that of boys. They found that there were no significant differences at the age of thirteen between the sexes on the same test.

A study by Sharma and Meighan (1980) which did make some attempt to take into account previous mathematical experiences found that there was very little overall difference in the performance of boys and girls. Sharma (1981) reports that boys and girls were classified into those with a science background (i.e. those entering 'O' level physics), those with a technical subject background (those entering 'O' level technical drawing) and those with a mathematics background. In all three groups there was very little difference between the overall performance of boys and girls. This leads Sharma and Meighan to conclude that if one aims to reduce the differences between sexes, attempts might have to be made to see that boys and girls opt to follow the same type of courses in equal proportions. However, as Wilson (1981) points out, perhaps what is more relevant is the fact that far more boys take maths 'O' level than girls and one ought to look into the causes of this rather than to coerce girls into studying physics with the aim of trying to improve their mathematical performance.

2 . 6 Attitudes To Mathematics.

Another area that may affect the performance of girls and boys in mathematics is their attitude towards the subject. Fennema (1974) comments that throughout school age neither sex consistently had more positive feelings towards mathematics but that "measures of attitudes are better predictors of mathematics - learning for girls than boys". Biggs (1962) reaches the same conclusions of boys and girls in primary and early secondary ages, but he feels that at the age of twelve or thirteen years of age girls begin to dislike arithmetic, while after the age of fourteen boys show an increasing liking for arithmetic and mathematics. He comments that "these trends in attitude patterns are accurately reflected in the studies of arithmetical attainment at this level".

Studies in the United States by Carey (1958) and Aiken (1970) both show that at college level (i.e. the 18 - 21 age range) males had a consistently more positive attitude towards mathematics. Carey concentrated particularly on problem solving, and he found that following a discussion with his subjects about the desirability of problem solving, women showed some inprovement in their attitude but there was no difference among the men. There was, in fact, no sex-difference in the attitude score after discussion. Also in the United States, Callaghan (1971) reported that thirteen year old boys and girls showed just as much dislike for mathematics, but that girls showed a much stronger dislike for word problems than did boys. The results of an international survey by Husen (1967) found that in all the populations, boys displayed more interest in maths than girls and this was also found by Douglas et al (1968).

As has already been mentioned, Preston (1972) reported that there was a difference in attitudes between girls in co-educational and single-sex schools. Overall he discovered that girls are less committed and interested in mathematics than boys and lack the foresight to apply the subject. Despite the fact that pupils in girls schools would appear to see mathematics in a rather closed and restricted situation, there is a significant increase in interest and commitment compared with girls in co-educational schools. Steedman (1980) comments that her findings are consistent with these differing attitudes in single-sex and co-educational schools.

Preece (1979) in a study of ability and attitude of secondary school children over the period of a year found that the attitude of the boys and girls was not noticeably different at the beginning of the year, but by the end of it the boys had increased attitude scores whilst the girls' decreased. The boys, it seemed were challenged by more difficult work, whereas the girls assumed an air of hopelessness. She concluded that "the female attitude is a deteriorating factor" and that techniques of perpetual encouragement and motivation seemed to improve the girls' attitudes. In questioning Preece's finding, Isaacson and Freeman (1980) feel that girls may drift away from mathematics because they see themselves as home makers rather than career people and might not be prepared to struggle with a difficult subject for only a few years benefit, whereas boys see a more long-term benefit. This, of course, leads into the area of sex-stereotyping. On the whole, however, there seems to be a lot of evidence that points to a strong correlation between attitude and attainment and if adolescent girls' attitude towards the subject could be improved then their performance might correspondingly be better.

2 . 7 Other Environmental Factors.

Perhaps we ought to look at the pre-school age to find fundamental reasons for the difference in male and female ways of thinking if indeed they do exist. Lynn (1962) suggests that the reason for boys supremacy in problem solving may lie in infant learning. Girls are brought up to learn female characteristics by imitating their mothers. Boys, on the other hand, have to learn male behaviour by abstraction in the absence of their fathers for much of the time. It is possible that these contrasting styles of learning manifest themselves in mathematics during adolescence. An interesting theory proposed by Hutt (1972) is that due to their earlier maturation, lack of nursery school education is likely to be a more severe deprivation for girls than for boys because between the age of three and five years the girls are passing through a proportionately greater part of their formative period. If girls of this age were exposed to materials whereby numerical relationships could be established, it may improve their skill in this area as they get older.

Finally, sex-stereotyping could play a major contribution in mathematical sex-differences. St. John-Brooks (1981) cites evidence by Ernest that mothers in the United States tend to help their children with homework in the early stages, but from the age of thirteen onwards their fathers become the main authority in mathematics. Hence mathematics becomes stereotyped as a male domain. Berrill and Wallis (1976) analysed the content of many mathematics text books and found that the examples and illustrations in the majority of them showed maths to be a male oriented subject which led them to comment that "in view of social prejudices outside school, we must avoid adding to them unnecessarily if we are going to help girls realise their full mathematical potential". Byrne (1978) feels that this identification with the male role leads boys to be more highly motivated in mathematics, and Nevin (1973) puts forward the idea that it might be girls interest in human relationships that acts as a barrier to such an abstract subject as maths. Clearly a lot more work needs to be done in this area in order that the effects of sex-stereotyping can be fully evaluated in relation to mathematical sex-differences.

2.8 Summary and Conclusion

It is clear that the claims made by Maccoby and Jacklin (1975), at least as far as mathematical and spatial sex-differences are concerned, are well substantiated by recent research. It also seems clear that the cause of these differences cannot be put down to one single factor. Even if genetic inheritance is a cause of mathematical sex-difference, and there is little conclusive evidence to say that it is, it is likely that it is greatly augmented by the environmental conditions imposed upon youngsters. It is unlikely that the "nurture" versus "nature" argument will ever be solved, at least until a lot more work has been done on the genetic make-up of males and females. It has been shown, however, that factors such as schooling, sex-stereotyping and the attitudes created by these factors may all affect mathematical achievement. How much these factors are interrelated and to what extent each affects the child's development is at present just not known. One possible interaction, proposed by Weiner (1980), is shown in Figure (ii).

The writer is forced to conclude that mathematics teachers must accept that sex-differences exist and try, through their teaching, to minimise them, if this is what society wants. Walkerdine and Walden (1981) of the "Girls and Mathematics" project write that "We need to start looking at mathematics as a social and historical product. If we look at specific practices in the teaching of maths, we can see how girls become good and bad".

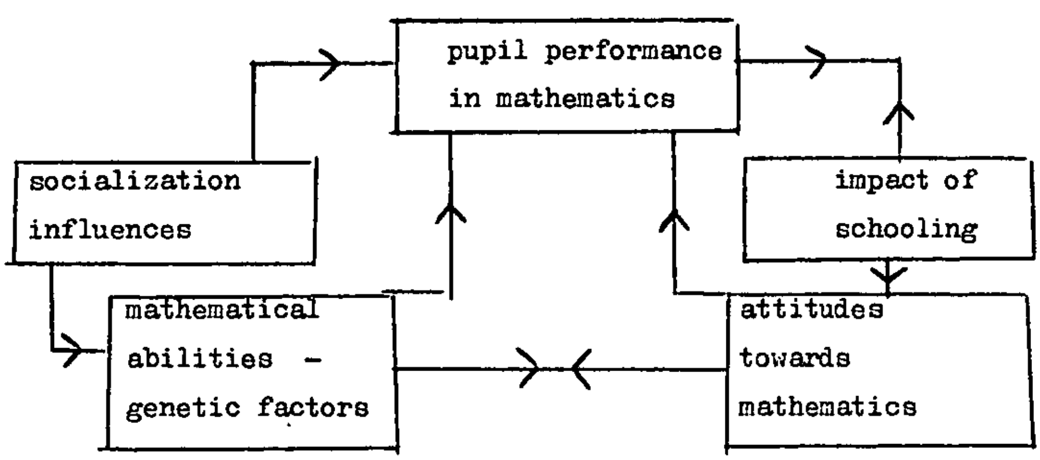

Figure (ii): The major influences on pupil performance in mathematics.

The remaining part of this dissertation deals with the development of mathematical sex-differences during the first year of secondary schooling and attempts to identify areas of the mathematics syllabus where these differences are particularly apparent. The writer feels that if such areas can be identified and maths teachers made aware that they exist then a different emphasis might be applied to the teaching of the subject in order to minimise such differences.

CHAPTER 3

EXPERIMENTAL DESIGN

3 . 1 Outline of Enquiry

The children used for the enquiry were a complete year of an 11 - 14 high school. On entry into the school the children were given mathematics and English attainment tests. The same children were given another mathematics attainment test one year later. By comparing the results of the two mathematics tests the following null hypothesis was tested:-

> "There will be no overall difference in mathematical attainment between the sexes at the age of 11+ or one year later. Neither will there be any specific area of mathematics where one sex out-performs the other".

The results of the English test were used to see whether there was any difference in correlation between maths and English for girls and boys.

3 . 2 The School

The school used for the enquiry is a well-established 11 - 14 high school in a village of about 4,500 population. Approximately two thirds of the children come to the school on buses from the surrounding villages so there is very little scope for after school activities. The area is a very stable one from the point of view of population movement, and it is generally felt by the staff that, for this reason, the average ability of the children is slightly below the national average and their individual abilities tend to be grouped towards the centre of the ability range rather than the extremes.

Traditional standards of discipline are expected from the children yet there are many progressive features of the curriculum. In the first year children are taught a common humanities course rather than the individual subjects of history, geography and religious education. In the third year all pupils are expected to tackle all aspects of the design course. In addition to this there are no formal examinations.

Pupils come to the school from twelve different primary schools, the two largest of which have two classes in their fourth years, whilst the smallest school has only one class for the whole of the junior age range. On entry to the school, pupils have, for the last seven years, been allocated to one of three bands:- upper, lower and remedial. Primary school recommendations have always played a major part in these allocations, but in the year in question this information was supplemented by the results of standardised tests in mathematics and English which the pupils were required to take on entry to the school. This resulted in a four form upper band, a four form lower band and two remedial classes.

On leaving the school, pupils transfer to one of two local upper schools. Some pupils can choose which to go to, but the majority are allocated on a geographical basis. The ratio of pupils transferring to each school is usually in the ratio of two to one.

In the year in question the results of the mathematics entrance test were used to put the children into maths sets as quickly as possible after entry, there being four sets in the upper band and five in the lower. Transfer between sets at a later date is fairly easy if a pupil's ability and/or effort merit it. The top two sets in the upper band use both modern and traditional text books (School Mathematics by H.E. Parr and the SMP letter series). The next four sets use Cornerstone Mathematics by R.E. Harris. Sets three and four in the lower band use Basic Skills in Mathematics by R.W. Fox and the bottom set is taught by a teacher from the remedial department. With this exception the remedial department is completely separate from the mathematics department. Within these sets teaching takes place on a class rather than an individual basis and work is tested at approximately monthly intervals rather than at the end of each term.

3 . 3 The Sample

As has been mentioned a complete year's intake, including children diagnosed as needing remedial treatment, were tested in mathematics and English on entry to the school. As far as possible the same children were tested in mathematics a year later. In all 272 pupils were tested in the first year and 257 in the second year. In order to compare the two years as accurately as possible the children chosen for analysis were those who were present for all three tests. This was 243 in all and of these, 111 were boys and 132 were girls. The results of all three tests were tested for normality by plotting the cummulative frequency on normal probability paper. The points were almost linear so the writer concludes that the sample used gave a reasonable approximation to the normal distribution. The resulting graphs can be seen in appendix (v).

3 . 4 The Tests

It was decided that the enquiry would use results that were readily available within the school. In the year in question, the tests used for the intake were the N.F.E.R. Mathematics Attainment Test DE1 (Test 253) and the N.F.E.R. English Progress Test D2 (Test 177) by Jennifer Henchman (see appendices (i) and (ii)). In order to measure mathematical progress the same children were tested one year later with the N.F.E.R. Mathematics Attainment Test EF (Test 263), this being the only appropriate mathematics attainment test that the N.F.E.R. produce for pupils in the 12+ age range (see appendix (iii)).

Mathematics Attainment Test DE1 consisted of 45 items all of which were open-ended type of question. The manual of instructions for this test stated that "With the children in the standardization sample, the superiority of boys over girls amounted to only 0.78 points of standardized score with a standard error of 0.32 points. The difference between the sexes is clearly not significant". The reliability coefficient of the tests was calculated to be o.96 (by Kuder-Richardson formula 20) leading to a value of 2.84 for the standard error of the test.

English Progress Test D2 consisted of 75 questions for which the children were required to write a word or a sentence as their answer. With the children in the standardization sample the superiority of girls over boys amounted to 4.39 points of standardized score with a standard error of 0.54. This difference, stated the manual, was significant. The reliability coefficient of the test was found to be o.97 (by Kuder-Richardson formula 20) which leads to a value of 2.71 for the standard error.

Mathematics Attainment Test EF consisted of 60 items, all of which were multiple choice, in which the correct answer had to be selected from five options. For children in the 12+ age group the difference between boys' and girls' standardized scores was 0.09 with a standard error of 0.60. The KR20 reliability coefficient of the test was o.92 giving a standard error of 4.34.

All children sat the two first year tests at the same time on the same day shortly after the start of the new school year. Ten different teachers were involved in the supervision of these tests, so, although they were all told to follow the manual of instructions, there were bound to be slight differences in the conditions under which the children sat the test. There was supposed to be no time limit set for these tests, though it was found impracticable due to timetable arrangements to allow the ch children more than one hour for each test. The manuals stated that in both tests average children should finish in forty-five to fifty minutes. The second year test was administered over a period of about one month from the beginning of the school year. Eight different teachers were involved and were again told to follow the manual closely. Children sat this test during mathematics lessons and fifty minutes was the time allowed as per the instructions in the manual.

Making and standardization of the first year tests was u undertaken by a team of about twenty teachers each making a page of script. The second year test was marked and standardized by the writer.

CHAPTER 4

RESULTS

4 . 1 Comparison of Overall Scores of Boys and Girls

Figure (iii) below shows the mean and variance for boys, girls and the complete sample for the tests in question. Boys are found to be ahead in both mathematics tests by 1.36 and 3.63 standardized points respectively. This compares with 0.78 and 0.09 points in the standardization sample. In the English test the girls are ahead by 2.49 points compared with 4.39 in the standardization sample. Being standardized tests, the overall mean for each test should be 100 and the standard deviation 15, giving a variance of 225. So the scores at 11+ appear to be below the national average and to be less widely distributed than would be expected. Yet at 12+ the scores have caught up and passed the national average and the variance appears to be nearer that which one would expect.

TEST	GROUP	NUMBER TESTED n	MEAN $\bar{x}$	VARIANCE s^2
MATHS DE1	BOYS	111	94.31	146.4
	GIRLS	132	92.95	100.4
	OVERALL	243	93.54	121.7
MATHS EF	BOYS	111	106.55	279.9
	GIRLS	132	102.92	170.1
	OVERALL	243	104.44	224.0
ENGLISH D2	BOYS	111	93.90	163.5
	GIRLS	132	96.39	158.5
	OVERALL	243	95.26	162.3

Figure (iii): Summary statistics of mathematics tests DE1 and EF and English test D2.

The N.F.E.R. (1981) give a number of reasons for the difference in means of the two tests. The inflation of scores on the second testing "could be due to differences in the standardization of the two tests ......'. Secondly, with a sample size of around 200 some deviation in the results from one test to another is almost inevitable. Finally, teaching styles, layout and content of the test can also affect a pupils performance. The writer feels that since the first year tests were administered shortly after the pupils had entered the school, an anxiety factor might be responsible for lowering the mean scores of the first year mathematics and English tests by a point or two. Despite this, the size in the increase in scores for the second year mathematics test is still surprising.

To test whether the differences between boys' and girls' mean scores in the mathematics tests were significant the variances and means were compared using an F- and t- test respectively. These tests are valid provided the population from which the sample is drawn is assumed normal and the observations are independent. It was decided to test at the five per cent significance level as this is a widely accepted level.

The F- test was used to test the null-hypothesis, Ho, that there was no difference between the variances of the mathematics marks obtained by girls and boys at either 11+ or 12+

$$F \text{ (calculated)} = \frac{S_B^2}{S_G^2}$$

$$\text{At } 11+, \quad F = \frac{146.4}{100.4} = 1.46$$

$$\text{At } 12+ \quad F = \frac{279.9}{170.1} = 1.65$$

The critical F value for 110 and 131 degrees of freedom at the five per cent significance level is 1.36. In both cases the calculated value of F is greater than the critical value of F at the five per cent level and in fact the 12+ value of F is greater than the critical F value at the one per cent level of significance (1.54). Hence the hypothesis is disproved and there is a significant difference in the variance of the boys' and girls' mathematics scores at both 11+ and 12+.

The t- test was used to test the null-hypothesis, Ho, that there was no difference in the mean mathematics scores of boys and girls at either 11+ or 12+.

$$t \text{ (calculated)} = \frac{\bar{x}_B - \bar{x}_G}{\sqrt{\dfrac{S_B^2}{n_B} + \dfrac{S_G^2}{n_G}}}$$

$$\text{At } 11+,\ t = \frac{94.31 - 92.95}{\sqrt{\dfrac{146.4}{111} + \dfrac{100.4}{132}}} = 0.94$$

$$\text{At } 12+,\ t = \frac{106.55 - 102.92}{\sqrt{\dfrac{279.9}{111} + \dfrac{170.1}{132}}} = 1.86$$

At the five per cent significance level the critical values of t are $\pm$ q1.97 for 241 degrees of freedom. Since $-1.97 < t$ (calculated) $< +1.97$ the null-hypothesis in this case is disproved neither at 11+ nor 12+. Therefore the mean scores of the boys and girls did not differ significantly at 11+ or 12+. However, there is evidence to suggest that the boys are beginning to increase the gap between themselves and the girls between the ages of eleven and twelve.

4 . 2 Correlations Between the Tests.

The Pearson product moment correlation coefficient (r), was calculated for each pair of tests for both boys and girls using a graphical method described by Kurtz and Mayo (1979). The graphs can be seen in appendix (iv). A transformation of the formula

$$r = \frac{N \Sigma XY - \Sigma X \Sigma Y}{\left[N \Sigma X^2 - (\Sigma X)^2\right]\left[N \Sigma Y^2 - (\Sigma Y)^2\right]}$$

was used, where N is the number of observations, and X and Y are the scores on the first and second variables respectively. The following correlation matrices were obtained.

BOYS, r	MATHS TEST DE1	MATHS TEST EF	ENGLISH TEST D2
MATHS TEST DE1	1	0.86	0.73
MATHS TEST EF	0.86	1	0.74
ENGLISH TEST D2	0.73	0.74	1

Figure (iv): Correlation Matrix For Boys.

GIRLS, r	MATHS TEST DE1	MATHS TEST EF	ENGLISH TEST D2
MATHS TEST DE1	1	0.82	0.79
MATHS TEST EF	0.82	1	0.81
ENGLISH TEST D2	0.79	0.81	1

Figure (v): Correlation Matrix For Girls.

The assumptions made in computing Pearson's r are that the units of measurement are equidistant throughout the range of scores involved and that the regression of the two variables is linear. Both these conditions are satisfied by the data in this experiment.

Not surprisingly the boys showed a higher correlation between the two maths tests than between the English test and either of the two maths tests. However all three correlations of the girls were very similar, and roughly in between the boys' maths tests correlation and English and maths correlations. Unfortunately it is difficult to interpret the significance of these differences since the samples involved are not independent random samples from the same population (see Lindquist (1940)).

However, it appears that the boys in the experiment were more consistent in their mathematics performances over the year than were the girls. It also appears that the girls' performances in English in the first year give as good a prediction of their performance a year later in mathematics as do their first year mathematics results. The higher correlation between English and maths for the girls might be interpreted in the following way. Girls who are good at mathematics are more likely to be good at English than boys who are good at mathematics.

The size of all the correlations lends support to the view that underlying intelligence is the most important factor in a pupil's performance in an academic subject. Obviously reading ability and comprehension play a very crucial part in tests of this nature, whatever subject is being measured.

4 . 3 Item Analysis.

In order to try and identify any particular areas of mathematics in which boys out-performed girls (or vice-versa) the responses to each question in the two mathematics tests were analysed and the percentages of boys and girls who answered each question correctly were recorded. It was noticed that when the answers were being analysed a much larger number of girls failed to finish, particularly in the second year test. It was therefore decided to omit the last seven items of test DE1 and the last fifteen items of test EF from the analysis of responses, although, of course, the standardized totals were used to compare the overall performances of boys and girls.

The results of test DE1 are shown in figure (vi) and for test EF in figure (vii). For the purpose of this analysis it was necessary to combine the items in both tests as there were insufficient questions on a particular topic to make any worthwhile comparisons over the year. In any case, the questions were of different types, those for DE1 being open response questions and those for EF being multiple choice.

In all, 83 items were analysed. Of these, boys came out on top in 41, girls in 31, and 11 items showed less than one per cent difference between the sexes. The largest difference in favour of the girls was 11.4% on item 1 . 27:-

"Fill in the box:- $4 + 2 = 12 \; \square \; 2$"

However, 11 of the questions in which the boys came out on top had percentage differences larger than this. The largest being 23.0% for item 2 . 30:-

"Which of the following fractions is the smallest?

a) $\frac{11}{12}$ b) $\frac{5}{6}$ c) $\frac{3}{8}$ d) $\frac{1}{9}$ e) $\frac{1}{4}$ "

On average 2.36% more boys than girls answered each question correctly.

It was thought desirable to check whether the percentage differences were significant for any of the items. The standard deviation of the difference between boys' and girls' scores is [illegible]

Figure (vi): Percentage responses to Mathematics Attainment Test DE1.

ITEM	CORRECT		INCORRECT		NO ATTEMPT	
	BOYS	GIRLS	BOYS	GIRLS	BOYS	GIRLS
1 . 1	85.6	93.9	11.7	4.6	2.7	1.5
1 . 2	87.4	81.1	9.0	13.6	3.6	5.3
1 . 3	75.7	72.7	9.9	12.1	14.4	15.1
1 . 4	61.3	68.9	28.8	27.3	9.9	3.8
1 . 5	54.9	56.8	25.2	18.2	19.8	25.0
1 . 6	55.9	50.8	16.2	20.5	27.9	28.8
1 . 7	55.9	40.2	27.9	36.4	17.1	23.5
1 . 8	61.3	63.6	27.0	31.1	11.7	5.3
1 . 9	45.0	45.5	43.2	43.2	11.7	11.4
1 . 10	91.9	96.2	2.7	0.8	5.4	3.0
1. 11	82.9	93.9	9.0	6.1	8.1	0
1 . 12	22.5	16.7	62.2	72.7	15.3	10.6
1 . 13	19.8	15.1	42.3	50.8	37.8	34.1
1 . 14	44.1	31.8	29.7	31.8	26.1	36.4
1 . 15	42.3	44.7	44.1	42.4	13.5	12.9
1 . 16	62.2	62.1	22.5	25.0	15.3	12.9
1 . 17	52.3	37.9	28.8	43.2	18.9	18.9
1 . 18	63.1	66.2	25.2	31.1	11.7	3.8
1 . 19	47.7	34.8	35.1	36.4	17.1	28.8
1 . 20	58.6	64.4	21.6	18.2	19.8	17.4
1 . 21	41.4	22.0	26.1	37.1	32.4	40.9
1 . 22	53.1	53.0	31.5	35.6	15.3	11.4
1 . 23	53.1	57.6	29.7	29.5	17.1	12.9
1 . 24	53.1	45.4	26.1	37.1	20.7	17.4
1 . 25	49.6	45.4	33.3	46.2	17.1	8.3
1 . 26	44.1	29.5	25.2	22.7	30.6	47.7
1 . 27	33.3	44.7	38.7	43.2	18.9	12.1
1 . 28	47.7	47.0	32.4	37.9	19.8	15.1
1 . 29	37.8	37.1	34.2	37.9	27.9	25.0
1 . 30	30.6	12.9	63.1	73.5	15.3	13.6
1 . 31	55.9	50.0	25.2	37.9	18.9	12.1
1 . 32	30.6	28.8	37.8	39.4	31.5	31.8
1 . 33	43.2	44.7	35.1	40.2	21.6	15.1
1 . 34	46.8	37.9	30.6	40.9	22.5	21.2
1 . 35	34.2	25.0	31.5	44.7	34.2	30.3
1 .36	37.8	37.9	35.1	35.6	27.0	26.5
1 . 37	36.9	22.7	42.3	64.4	20.7	12.9
1 . 38	45.0	50.0	26.1	37.9	28.8	12.1

Figure (vii) Analysis of results of Mathematics Attainment Test EF (percentage responding to each distractor with key responses underlined).

ITEM	A		B		C		D		E		NO ATTEMPT	
	BOYS	GIRLS	BOYS	GIRLS	BOYS	GIRLS	BOYS	GIRLS	BOYS	GIRLS	BOYS	GIRLS
2.1	89.2	86.4	1.8	0.8	2.7	3.8	0.9	2.3	4.5	3.8	0.9	3.0
2.2	2.7	11.4	9.0	10.6	0	2.3	82.0	72.0	4.5	2.3	1.8	1.5
2.3	70.3	62.1	22.5	28.8	4.5	2.3	1.8	2.3	0	3.0	0.9	1.5
2.4	10.8	13.6	5.4	5.3	9.0	3.0	49.5	55.3	5.4	3.0	19.8	19.7
2.5	37.8	43.2	2.7	3.0	5.4	2.3	2.7	2.3	46.8	45.5	4.5	3.8
2.6	1.8	1.5	3.6	3.8	82.9	87.9	5.4	1.5	1.8	1.5	4.5	3.8
2.7	1.8	0.8	1.8	0	90.1	95.5	2.7	0.8	0.9	1.5	2.7	1.5
2.8	14.4	22.0	39.6	42.4	6.3	3.0	9.9	3.8	19.8	19.7	9.9	9.1
2.9	1.8	3.0	4.5	5.3	3.6	2.3	9.0	9.8	75.7	77.3	5.4	2.3
2.10	3.6	11.4	50.5	50.7	31.5	28.8	2.7	2.3	5.4	3.0	6.5	3.8
2.11	25.2	16.7	1.8	3.0	2.7	0.8	3.6	1.5	62.2	73.5	4.5	4.6
2.12	11.7	6.8	6.3	3.0	4.5	6.8	62.2	72.7	11.7	5.3	6.3	5.3
2.13	16.2	8.3	7.2	7.6	10.8	13.6	7.2	15.2	55.0	55.3	3.6	0
2.14	15.3	20.5	3.6	3.0	68.5	63.6	0.9	0	8.1	9.1	3.6	3.8
2.15	0.9	3.8	0	0	18.0	13.6	2.7	0.8	73.9	78.0	4.5	3.8
2.16	3.6	2.3	12.6	12.1	1.8	1.9	74.8	79.5	4.5	0.8	2.7	3.8
2.17	1.8	9.8	27.9	37.1	63.1	50.0	2.7	2.3	0.9	0	3.6	0.8
2.18	69.4	66.7	3.6	0.8	0.9	2.3	4.5	0	14.4	26.5	7.2	2.3
2.19	0	0.8	43.2	47.7	45.0	44.6	0.9	2.3	2.7	1.5	8.1	3.0
2.20	4.5	4.6	7.2	3.0	69.4	71.2	4.5	2.3	4.5	6.8	9.9	12.1
2.21	69.4	71.2	7.2	6.8	0.9	0.8	12.6	13.6	0.9	3.0	9.0	4.6
2.22	1.8	3.8	71.2	59.8	9.0	9.1	2.7	6.8	5.4	9.8	9.9	10.6
2.23	47.7	38.6	12.6	6.1	6.3	1.5	21.6	34.8	4.5	2.3	9.0	16.7
2.24	6.3	7.6	54.9	55.3	8.1	5.3	9.9	11.4	14.4	18.9	4.5	1.5
2.25	8.1	8.3	6.3	7.6	52.3	49.2	17.1	18.9	9.0	12.9	7.2	3.0
2.26	35.1	38.6	3.6	4.6	6.3	3.0	3.6	9.8	44.1	34.1	7.2	6.8
2.27	9.9	12.1	14.4	19.7	64.9	56.1	4.5	7.6	0.9	2.3	5.4	2.3
2.28	4.5	3.0	6.3	11.4	11.7	15.9	53.6	50.0	10.8	15.2	8.1	4.6
2.29	11.7	22.0	9.0	5.3	6.3	7.6	6.3	12.9	56.8	47.0	9.9	5.3
2.30	27.0	42.4	1.8	3.0	1.8	3.8	49.5	26.5	15.3	23.5	4.5	0.8
2.31	9.9	14.4	65.8	56.8	7.2	10.6	4.5	9.1	7.2	4.6	5.4	4.6
2.32	69.4	60.6	10.8	9.1	6.3	15.9	2.7	2.3	6.3	6.1	4.5	5.3
2.33	11.7	14.4	50.5	50.8	10.8	6.8	6.3	5.3	9.9	8.3	10.8	14.4
2.34	3.6	6.8	5.4	5.3	46.8	37.9	11.7	11.4	18.0	25.0	14.4	13.6

ITEM	A		B		C		D		E		NO ATTEMPT	
	BOYS	GIRLS	BOYS	GIRLS	BOYS	GIRLS	BOYS	GIRLS	BOYS	GIRLS	BOYS	GIRLS
2.35	4.5	3.8	71.2	68.2	3.6	5.3	12.6	16.7	2.7	3.8	5.4	2.3
2.36	12.6	18.2	20.7	14.4	21.6	23.5	19.8	22.0	8.1	15.9	17.1	6.1
2.37	14.4	18.9	9.9	17.4	16.2	9.8	18.9	20.5	24.3	25.0	16.2	8.3
2.38	4.5	6.8	12.6	28.8	15.3	6.1	45.0	25.8	3.8	9.1	18.9	23.5
2.39	6.3	9.1	28.8	26.5	10.8	11.4	8.1	13.6	25.2	13.6	20.7	25.8
2.40	27.0	20.5	7.2	5.3	28.8	25.0	7.2	14.4	9.0	9.8	20.7	25.0
2.41	20.7	15.9	10.8	9.1	11.7	15.2	5.4	11.4	40.5	41.7	10.8	6.8
2.42	4.5	2.3	83.8	87.1	1.8	0	0.9	3.0	3.6	3.0	5.4	4.6
2.43	74.8	78.8	2.7	0.8	1.8	1.5	13.5	12.9	1.8	0.8	5.4	5.3
2.44	1.8	0.8	2.7	3.0	78.4	85.6	4.5	0.8	8.1	5.3	4.5	4.6
2.45	37.8	40.2	9.0	6.1	21.6	17.4	10.8	16.7	1.8	3.0	18.9	16.7

given by the formula

$$\sigma = \sqrt{N_f \; p_f \; q_f + N_m \; p_m \; q_m}$$

where N = number of observations

p = the proportion of the female (or male) score out of the total possible score.

and q = 1 - p

The difference between the percentages is significant at two standard deviations, and these significance levels and the percentage differences for each item are given in appendix (iv). It was found that the differences of eight of the items were significant - one in favour of the girls and seven in favour of the boys.

In order to try and discover whether there was a common thread in the questions for which boys out-performed girls, it was necessary to categorise the questions according to their content. A list was already available in the manual for Test EF and the writer attempted a similar classification for the items in TEST DE1.

The item classification and the average percentage by which one sex out-performs the other in each of the sub-categories is shown in figure(viii). In many of the sub-categories there are too few items from which to make observations, but in others there are striking sex-differences.

In the number category there was very little overall difference between the sexes. Girls seemed to be able to handle simple questions on the four rules better than boys, but this was cancelled out by boys superior understanding of place value and their ability to estimate.

In the section on fractions, 10.6% more boys on average answered the questions correctly, ranging from item 2.30 which 23% more boys answered correctly to item 2.20:-

"2 out of 6 is equivalent to

a) 1 b) $\frac{5}{9}$ c) $\frac{1}{3}$ d) $\frac{1}{19}$ e) $\frac{1}{2}$ "

which 1.8% more girls answered correctly. Of the nine questions in this category the difference in favour of boys was significant in four of them (items 1.21, 2.30, 2.38 and 2.39).

The 11 items on geometry showed a slight advantage to the boys overall, but it is interesting to look at the differences in the sub-categories. Boys could identify two-dimensional shapes and convert turning to degrees better than girls. Surprisingly, girls were more able to identify the nets of polyhedron and recognise similar triangles. In every sub-category where girls out-performed boys they did so on every question and vice-versa.

In the data representation section, again boys were slightly favoured overall, but in the sub-category dealing with bar charts girls did better, significantly so on item 1.11 which dealt with reading off the height of a column. Boys were better at answering

Category	Sub-Categories	Item Numbers	No. of Items	% Average Ahead
Number	Overall		31	Boys 0.24
	Four Rules	1.1, 1.2,1.3, 1.8,1.27,1.28 2.4	7	Girls 2.40
	Place Value & Estimation	1.4,1.6,1.25 2.1,2.25,2.26	6	Boys 2.73
	Problems	1.9,1.18,1.23 1.29,1.33,1.35 1.38,2.45	8	Girls 0.89
	Bases	1.13,1.15,1.16	3	Boys 0.80
	Number Patterns	1.34, 2.13	2	Boys 4.30
	Directed Numbers	2.18 2.19	2	Girls 0.75
	Powers	2.24,2.34,2.41	3	Boys 2.43
Fractions		1.21,2.17,2.30 2.38,2.39,2.40 2.20,2.21,2.22	9	Boys 10.60
Geometry	Overall		13	Boys 0.66
	2-D Shapes	2.2,2.3	2	Boys 9.10
	3-D Shapes	2.10,2.11,2.12	3	Girls 7.40
	Similarity	2.42,2.43,2.44	3	Girls 3.17
	Angle Concepts	2.27,2.28,2.29	3	Boys 8.33
	Angle Calculation	2.36,2.37	2	Girls 1.45
Data Representation	Overall		11	Boys 0.69
	Bar Charts	1.10,1.11,1.12, 2.5,2.6,2.7	6	Girls 2.93
	St. Line Graphs	1.31,1.32,2.31 2.32,2.33	5	Boys 5.04
Decimals & Percentages		1.20,2.14,2.15 2.16, 1.26	5	Boys 0.98
Measurement		1.30,1.37,2.9,	3	Boys 10.70
Algebra		2.8, 2.23	2	Boys 3.15
Rate, Ratio and proportion		1.5,1.7,1.14, 1.17,1.19,1.22 1.24,1.36,2.35	9	Boys 7.10

Figure (viii) Item classification of Tests DE1 and EF.

questions on straight line graphs.

Boys also come out on top in almost all questions involving rate, ratio and proportion. Over all nine questions they were on average 7.1% more successful than girls. Only item 1.7:-

"My watch gains 2 seconds every hour. After how many hours will it have gained a minute?"

was the boys' superiority significant, however.

Of the remaining three categories there was very little difference in the decimal and percentage section. The measurement and algebra categories had very few items in them, but it is worth noting that the differences in favour of the boys for items 1.30 - a length question, and 1.37 - a question on volume, were both significant, indicating that boys seem to be superior to girls in questions involving measurement.

4 . 4 Null Response and Error Analysis.

The writer felt that the boys' improved performance on the second mathematics test might be due to the fact that it was a multiple choice test and that boys might be inclined to have a go and guess at the answer whereas the same might not be true of girls. If anything, the reverse seemed to be the case. In test DE1 the questions were left unanswered by 19.4% of the boys on average, and only 14.9% of the girls. In test EF, as might be expected, the percentages were much lower. Eight per cent of the boys did not attempt each question on average, compared with 6.9% of the girls. The higher percentages for the boys were probably the result of a number of remedial boys in the sample who, particularly in the first year, attempted very few questions.

The percentages of boys and girls who did not answer a particular question was very similar for many of the questions and the difference was greater than 5% on only 20 of the 83 items (three quarters of these occuring in test DE1). Five of these differences were significant. Items 1.11, 1.18, 1.38 and 2.36 were attempted by significantly fewer boys and item 1.26, a question on percentage, by significantly fewer girls. There was no obvious pattern in favour of either sex or in the subject categories in which these larger differences occured, although a more detailed analysis may have shown some pattern.

These results seem to suggest that girls were at least as susceptible to guessing as boys.

The responses for each item in test EF were examined to see if either sex showed a particular preference for any of the distractors. Again what was apparent was the similarity of boys and girls in choosing wrong answers. Usually, only when one sex had a much higher percentage correct than the other was there any sex difference in the percentages choosing the distractors. Then the weaker sex tended to go for the same distractor, for example in item 2.38

"To which of the following fractions is 0.60 equivalent

a) $\frac{9}{25}$ b) $\frac{4}{15}$ c) $\frac{4}{9}$ d) $\frac{3}{5}$ e) $\frac{9}{20}$ "

boys were 19.2% more successful than girls. However, 16.2% more girls than boys chose option (b). This similarity of percentages was typical of many of the questions where there was a large sex-difference in the correct answer, suggesting that the choice of wrong answer is not purely arbitrary but that the sexes think differently about certain aspects of mathematics. A far more detailed analysis would again be required to substantiate this and it would be necessary to interview a sample of the children about the way in which they tackle questions.

CHAPTER 5

CONCLUSIONS

5 . 1 From Previous Research

1) Up to the age of eleven there is very little difference in the mathematical ability of boys and girls. If anything, girls seem to be slightly ahead of boys. Once at secondary school boys' mathematical skills develop more rapidly than girls' and the higher that one looks up the educational ladder, the larger the differences seem to become. These differences manifest themselves in two different ways. From eleven to sixteen, where there is little or no opportunity to drop maths from the course of study, the average performance of boys exceeds that of girls. At a higher level where students can choose to study certain subjects far more males than females opt to study mathematics. It must be pointed out, however, that at any stage the difference within the sexes is much greater than any difference between the sexes.

2) The cause of these sex-differences is a complex interaction of biological, personal, educational and social factors, the relative importance of each of which, or how one affects another, is just not known at the present time.

5 . 2 From This Enquiry.

Since the results of this study were taken from readily available data from a single school it is worth bearing in mind this comment of Entwistle and Nisbet (1972) when considering the following conclusions.

> "Results based on research in a single institution must be treated with caution. Differences between schools and between teachers may affect the observed relationships in unknown ways and hence replications in other schools

would be necessary before such results could be accepted."

3) The scores of the boys in the mathematics tests are significantly more variable than the scores of the girls. This agrees with the results found by Pidgeon (1967) in the National Study of 1964, and according to Hutt (1972) is a characteristic of many male and female features and functions, intellectual or otherwise.

4) There is no significant difference in the mean mathematics scores of boys and girls at 11+ or 12+. However, the boys' mean scores were higher in both years and the gap between the boys and girls had increased at 12+ from 1.36 standardised points at 11+ to 3.57 standardised points. This seems to bear out paragraph 1 of the conclusion derived from previous research.

5) There is a higher correlation between boys' mathematics scores over the two tests than between the girls' scores indicating that the boys performed more consistantly that the girls. The correlation between English and maths was almost the same as the correlation between both maths tests for the girls. However, the correlation between English and maths was lower than this for the boys. This indicates that girls who do well in English are more likely to do well in maths than boys who perform well in English.

6) The boys in the sample are more able to deal with questions involving fractions, proportionality and measurement than girls. Wood (1976) found that at 'O' level boys performance exceeded that of girls in questions involving scaling measurement, probability and space-time relationships. In a further report, Wood (1976a) argues that the common thread running through all these questions is comparison. It would seem, since the three areas of this report mentioned above are the ones which carry the largest sex-differences, that comparison is indeed an area

in which girls' ability is inferior to boys' because this is a basic concept underlying all three areas. The A.P.U. Primary Survey (1980 a)also shows boys to be significantly ahead in measurement of length, area and volume and rate and ratio.

7) In questions involving number there was little overall difference between boys and girls. However, girls seem to be able to handle questions involving simple computation better than boys but boys seem to have a better understanding of the size of numbers, which again involves comparison. Ward (1979) published his report of a survey undertaken in 1974 to investigate the competence of primary school children in mathematics. Each question was answered by more than 500 ten-year-olds and Ward noted that "the girls in the sample did slightly better at straight forward computation than the boys. The boys made up for this by performing slightly better on problems in words and those involving the structure of number". Shuard (1981) argues that these differences were much sharper than Ward suggests but they seem to be confirmed by the results of the current enquiry. Strangely, though, the girls in the sample were slightly better at problem solving than the boys and this contradicts the results of Ward and the A.P.U. (1980a).

8) Although there was little overall difference in questions involving geometry, boys dealt with questions on two dimensional shapes, and angles as part of a turn, better than girls. Girls on the other hand were far superior on three-dimensional shapes and similarity. As has been mentioned in chapter two, boys superiority in spatial concepts is well-recognised and although Wrigley (1958) warns that ability in geometry and spatial ability are not necessarily the same thing an examination of the items in questions

shows that they are all essentially spatial. So it seems strange that the girls should out-perform the boys in these questions, particularly since Sharma (1979) found that girls avoided three-dimensional questions at 'O' level.

9) The way in which the sexes tended to choose the same wrong response in the multiple choice questions of the 12+ mathematics tests seems to indicate that the thought processes of the boys and girls in the sample are different in some way.

5 . 3 Implications For Teaching

Having established that there are sex-differences in mathematics, and that it is possible to identify certain areas of the mathematics curriculum where such differences are more prominent, it is necessary to decide what to do about them. Fennema (1974) believes that there is a moral responsibility resting on teachers to give girls equal opportunities to learn mathematics. There are two ways in which "equal opportunities" can be interpreted. Should girls and boys be exposed to identical teaching and allowed to develop in their own ways with the resulting sex differences that have been observed? The alternative is to try and compensate in our teaching for these differences in order that they disappear. It may be that it is impossible to change such well-established patterns but it would be necessary to experiment to find out whether this is so.

It is beyond the scope of this report to argue about what "equal opportunities" means but assuming that cognitive sex-patterns can be changed by teaching, how are teachers to go about doing this? It has been shown that specific areas of weakness do exist for girls and a different approach to teaching these may be the answer. The writer feels, though, along with many other researchers, that if an answer to the problem is to be found it lies much earlier in school or even in pre-school life. A thorough examination of the practical experiences given to girls and boys in their formative years may yield the solution if one is to be found.

5 . 4 Suggestions For Future Work.

1) In view of the comment of Entwistle and Nisbet (1972) on the validity of drawing conclusions from single school samples, it would be necessary to substantiate or contradict the conclusions drawn with data obtained from a cross-section of other schools in order to state them without reservation.

2) It would be interesting to see how the children in this survey develop as they get older and, indeed, how they perform in public examinations. It would then be possible to see how results at 11 act as predictions for results at 16 or even 18 years of age.

3) The survey made use of readily available data and although some specific areas of sex-differences were identified it may be that there are others which were not thrown up by the questions in the tests. To ensure that a complete picture was produced it would be necessary to produce a battery of tests dealing with each area of the mathematics curriculum. These tests would involve different and wider areas as the children got older. With a more complete picture it may be easier to identify factors causing sex-differences in mathematics.

4) To see whether the mathematical thought processes of boys and girls are different a more rigorous analysis of the responses of both multiple choice and open-type questions could be undertaken, along with a series of interviews with a selection of the children involved.

5) Experiments could be set up to see whether different emphases in teaching mathematics do, in fact, alter the differences between the sexes in some way. Practical experience in the infant and nursery school could be monitored to ensure that girls do as much practical work as boys, or even more if possible. This would be a long-term, but possibly very rewarding, experiment in that it would be necessary to observe performances throughout the school careers of these children, but it might give the solution to the problem and end speculation about the causes of sex-differences. A more short-term experiment might be to change the emphasis in the teaching of certain areas of the curriculum in the secondary school to see whether this has any effect on reducing sex-differences in those particular areas of mathematics.

This current report only scratches the surface of the problem. Although new data is being produced all the time, the latest of which comes from the Primary and Secondary Survey Reports (No 2) from the Assessment of Performance Unit (1981a,b), it is evident that if sex-differences in mathematics are to be fully understood much further work is required on the subject.

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APPENDIX (i)

TIONAL FOUNDATION FOR EDUCATIONAL RESEARCH IN ENGLAND AND WALES

'est 253

MATHEMATICS ATTAINMENT TEST DE1

FILL IN THE FOLLOWING PARTICULARS

NAME ______________________ BOY OR GIRL ____________

SCHOOL ______________________ CLASS ____________

DATE OF BIRTH ______________ TODAY'S DATE ____________

O NOT turn over
R open this booklet until you are told to do so

READ THE FOLLOWING CAREFULLY

. Work carefully, and write your answers clearly. Do your working in the margin.
2. If you make a mistake, just cross it out and write down the correct answer.
3. If you cannot do a question, leave it and go on to the next one
4. You will have plenty of time to do the test.

NOT TO BE FILLED IN BY PUPIL

		1(9)	2(5)	3(7)	4(9)	5(5)	6(6)	7(4)	TOTAL(45)
SCORE	R								
	W								

AGE
YEARS
COMPLETED MONTHS

STANDARDIZED SCORE

INITIALS OF MARKER

Do not write here	
1	....
2	....
3	....
4	....
5	....
6	....
7	....
8	....
9	....
TOTAL R	
TOTAL W	

1. Write the missing number in the box.

$$12 \times \boxed{} = 36$$

2. Study the two examples given.

Examples: (a) $4 \times 11 = 44$ (b) $4 \times 5 = 20$
$8 \times 11 = 88$ $8 \times 5 = 40$

Now complete this statement.

$4 \times 25 = 100$
$8 \times 25 =$ ....

3. $16 \times 22 = 352$

Therefore $352 \div 16 =$ ....

4. Which of the following is nearest to 701×7? Draw a ring round it.

7701 7017 70000 4900 5917

5. I travel 25 kilometres in half an hour in my car. What is my average speed in kilometres per hour? ....km p.h.

6. Write down the number which is the sum of eight tens, seven thousands, one unit and four hundreds. ....

7. My watch gains 2 seconds every hour. After how many hours will it have gained a minute? ....hours

8. Fill in the 3 missing numbers in this sum.

ADD

```
   6 ... 3
+ ... 8 ...
  -------
   9  2  4
```

9. A litre bottle of ginger beer costs 12p, but 2p are given back when the bottle is returned. If I buy 8 litre bottles of ginger beer, how much will they have cost me if I return the bottles? ....p

GO STRAIGHT ON TO THE NEXT PAGE

(9)

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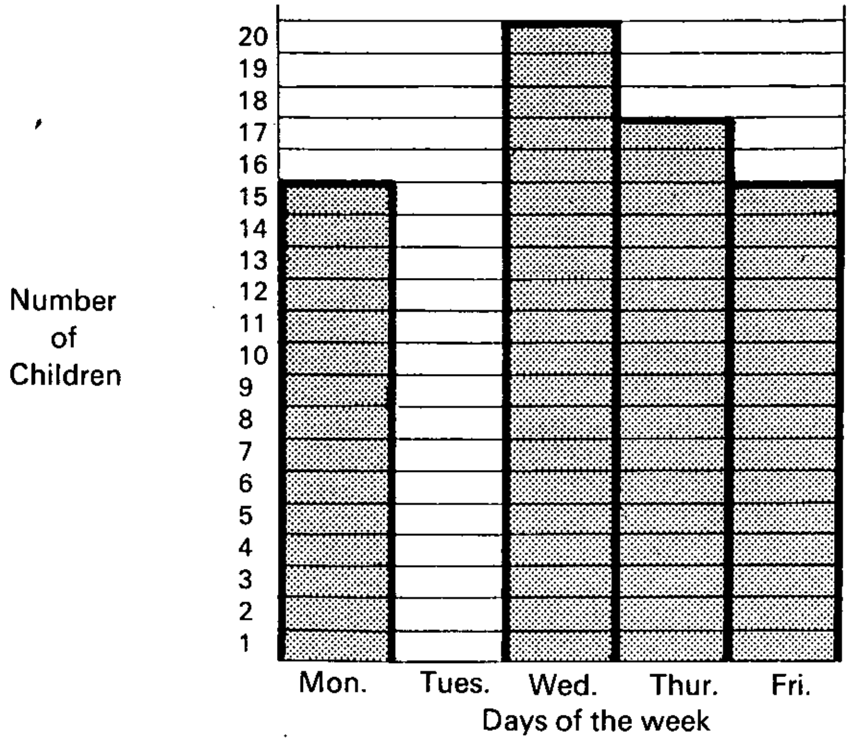


Here is a graph showing how many children were at school each day for a week. 'he total number of children in the class is 20.

0. Fill in the column for Tuesday to show that 18 children were in school that day. 10 ....

1. How many children were at school on Thursday? .... children 11 ....

2. What was the average number of children at school each day that week? .... children 12 ....

---

3. This addition is correct. **ADD**

Rigs	Regs
6	3
+ 2	2
9	1

How many regs are worth one rig? .... regs 13 ....

---

4. A stone weighing 1 kilogram is put into a tank of water. The water rises 4 centimetres.

If a stone of the same type weighing 250 grams was put into the tank, how much would the water rise? (There are 1000 grams in a kilogram) .... cm 14 ....

GO STRAIGHT ON TO THE NEXT PAGE

TOTAL	R
	W

In the imaginary land of Lusitouria objects are counted in fours and units instead of tens and units.

So six objects would be written

fours	units
1	2

meaning one four and two units, and

eleven objects would be written

fours	units
2	3

meaning two fours and three units.

15. How would eight objects be written in fours and units?

fours	units

16. How would thirteen objects be written in fours and units?

fours	units

17. My car uses 4 litres of petrol every 45 kilometres. I am going on a journey of 180 kilometres. How many litres of petrol will my car use for the journey? .... litres

18. Three cups of tea and three cups of coffee cost me 30p altogether. The cost of one cup of tea is 4p. What is the cost of one cup of coffee? .... p

19. Five coins weigh approximately 200 grams. How many coins weigh approximately 1 kilogram? (1000 grams = 1 kilogram) .... coins

20. Study the two examples given.

Examples: (a) $294{\cdot}7 \div 10 = 29{\cdot}47$
(b) $56{\cdot}85 \div 10 = 5{\cdot}685$

Now do this one.

$921{\cdot}3 \div 10 =$ ....

21. What is $\frac{1}{2}$ of $\frac{1}{3}$? ....

GO STRAIGHT ON TO THE NEXT PAGE

Do not write here	
15	....
16	....
17	....
18	....
19	....
20	....
21	....
TOTAL	R
	W

Do not write here

22. There are 840 children in a school. There is one teacher for every 20 children. How many teachers are there in the school? .... teachers | 22 ....

23. Some bars of soap cost $4\frac{1}{2}$p each or 11p for three. How much money do I save altogether by buying three at once instead of one at a time? ....p | 23 ....

24. If $2\frac{1}{2}$ centimetres were the same length as one inch, how many centimetres would there be in twelve inches? .... cm | 24 ....

25. $65 \times 15 = 975$
Which of the following is nearest to 65×30? Draw a ring round it.

6530 2000 9751 9750 1405 | 25 ....

26. What is 10% of 200? .... | 26 ....

In each of these sums one of the signs +, −, ÷, × is missing. Write the missing signs in the boxes. The first one has been done for you.

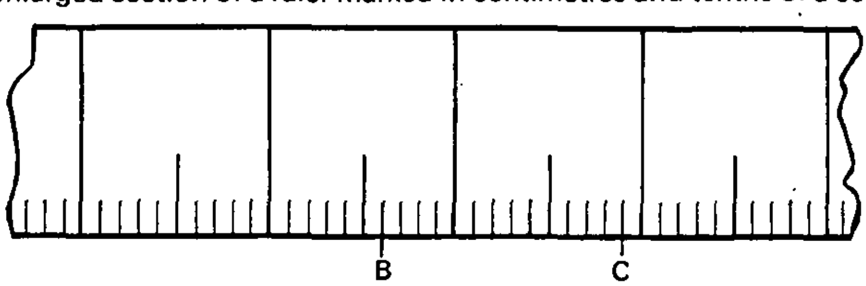
$2 \times 8 = 4$ $\boxed{\times}$ 4

27. $4 + 2 = 12$ $\boxed{}$ 2 | 27 ....

28. $4 + 6 = 16$ $\boxed{}$ 6 | 28 ....

29. In German money 100 Pfennigs are worth one Mark. One ice-cream cost me 40 Pfennigs. How much would 7 ice-creams cost in Marks and Pfennigs? ......Marks ......Pfennigs | 29 ....

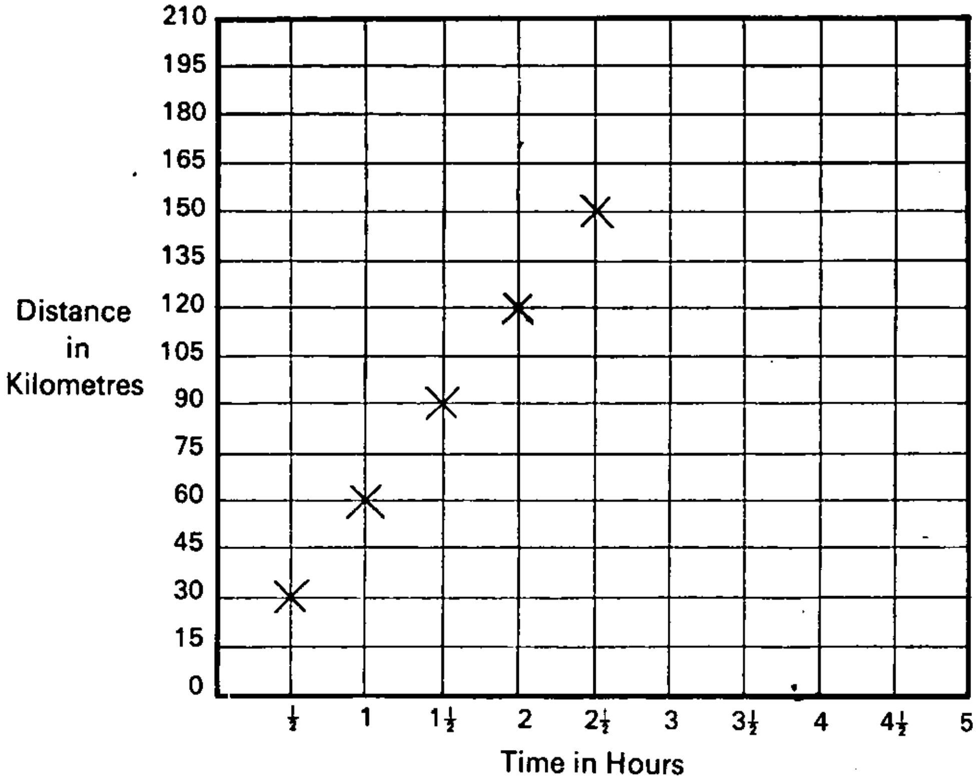
Here is an enlarged section of a ruler marked in centimetres and tenths of a centimetre.



30. What is the distance between B and C? .... cm | 30 ....

GO STRAIGHT ON TO THE NEXT PAGE

TOTAL R ....
W ....



Do not write here	

This graph shows how long a train takes to travel various distances. It travels at the same speed all the time.

31. Mark the next cross on the graph to show how far the train will have gone in 3 hours. 31 ....

32. Work out from the graph the speed of the train in kilometres per hour. ....km p.h. 32 ....

33. I flew from London to New York. The flight took 4 hours. I left at 6 p.m. but when I arrived in New York the clocks said 5 p.m. How many hours behind London time is New York time? .... hours 33 ....

34. The numbers on the left are connected in some way with the numbers on the right. Fill in the missing number.

3	9
10	100
2	4
7	

34 ....

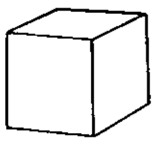
35. A litre bottle of lemonade costs 10½p.
A 4 litre jar costs 35p.
How much will I save by buying 8 litres of lemonade in 4 litre jars instead of litre bottles? ....p 35 ....

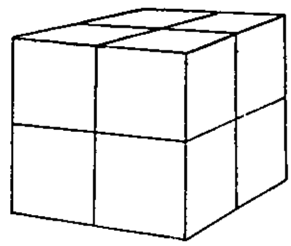
GO STRAIGHT ON TO THE NEXT PAGE

TOTAL	R
	W

Do not write here

36. A record goes round 45 times in one minute, It plays for $2\frac{1}{2}$ minutes. How many times has it been round on the turntable since it started to play? .... times 36 ....

Box A 

Box B 

37. Box B is twice as long, twice as wide and twice as high as Box A. Box A holds 1 kilogram of sugar. How much will Box B hold? .... kilograms 37 ....

38. Share 14p among three children so that one gets 2p more than each of the others, who both get the same amount.

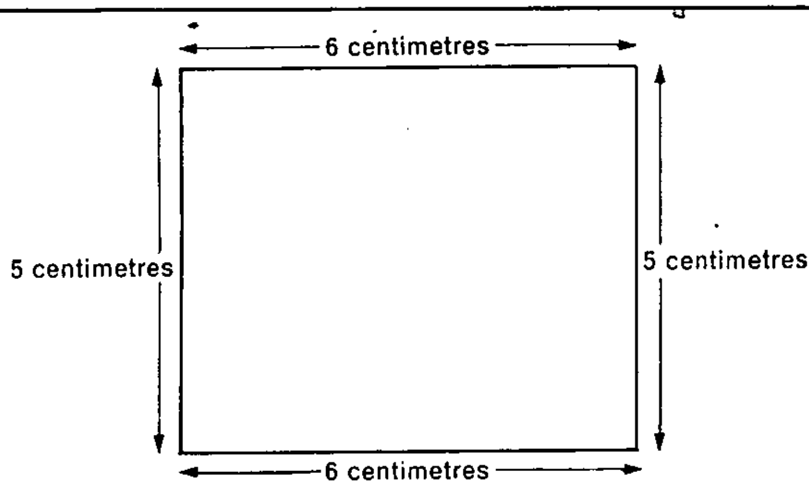
One child receives ....p

The other two children receive ....p each. 38 ....

39. $\frac{4}{5}$ of the children in a school are younger than 11 years old. How many is this if there are 300 children altogether in the school? .... children 39 ....

40. I weighed a suitcase in grams. Mistakenly thinking that there were 100 grams in a kilogram, I told my friend that it weighed 120 kilograms. How much did it really weigh?
(There are 1000 grams in a kilogram) .... kilograms 40 ....

41.

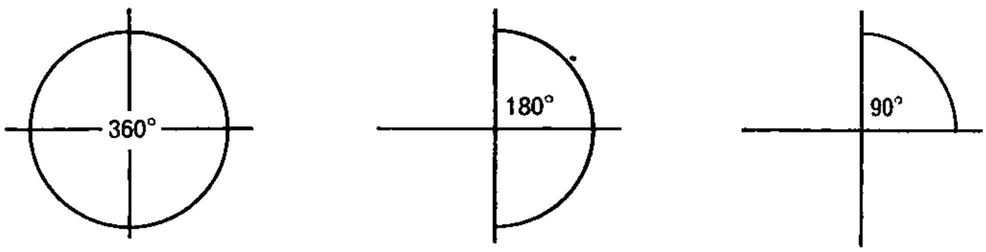


Here is a plan of a classroom. We cannot draw it full size, so in our drawing 1 centimetre means 2 metres in the classroom. What is the area of the classroom? ....square metres 41 ....

GO STRAIGHT ON TO THE NEXT PAGE

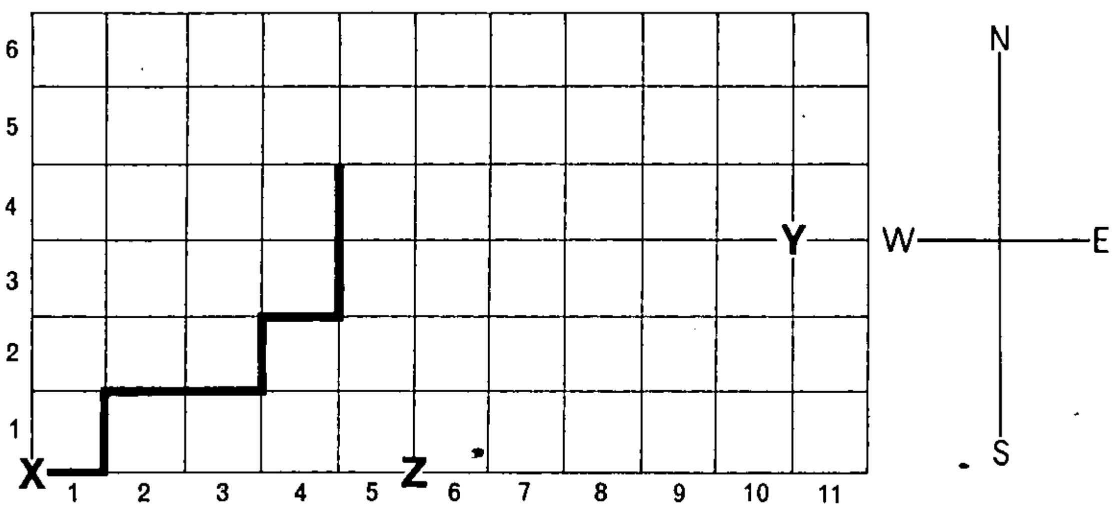
TOTAL	
R	
W	

Do not write here



42. Through how many degrees would the hour hand of a clock turn between 12 o'clock and 9 o'clock? ....° 42 ....

43. In a sale, 25% reductions are offered on all goods. For example, a jumper which cost £4 now costs only £3. What will be the sale price of a scarf which cost 48p originally? ....p 43 ....



ENEENENN. This is a code to explain the route shown on the diagram. Starting at **X** we go one square to the East, one to the North, two to the East, one to the North, one to the East and two to the North.

44. On the diagram plot clearly the route you follow for this code, starting at **Z**:
EENNNENEEN
44 ....

45. Make up a code for yourself showing any route you could use to get from **X** to the place marked **Y**. (It does not matter if it touches another route.)
.... 45 ....

TOTAL R W

(4)

END OF TEST

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APPENDIX (ii)

NATIONAL FOUNDATION FOR EDUCATIONAL RESEARCH IN ENGLAND AND WALES

Test 177

ENGLISH PROGRESS TEST D2

BY JENNIFER HENCHMAN BA Dip Ed

FILL IN THE FOLLOWING PARTICULARS

NAME ______________________________ BOY OR GIRL ____________

SCHOOL ______________________________ CLASS ____________

DATE OF BIRTH ____________________ TODAY'S DATE ____________________

DO NOT turn over

OR open this booklet until you are told to do so

NOT TO BE FILLED IN BY PUPIL

		1(13)	2(13)	3(11)	4(9)	5(8)	6(10)	7(11)	TOTAL(75)
SCORE	R								
	W								

AGE
YEARS
COMPLETED MONTHS

STANDARDIZED SCORE

INITIALS OF MARKER

PAGE ONE	Do not write in this column

In each sentence below, write in the brackets a word formed from the word printed large on the left of the sentence. Do NOT write any words ending in "ing" or "ness". TAKE CARE TO SPELL THE WORD CORRECTLY. The first one has been done for you.

TOLERATE The manager was a (tolerant) man who tried to understand other people's problems.

1. SHOOT When he fired his gun, the sound of the (..................................) was heard a long way off. 1 ....
2. PUBLISH The (...) asked to see the original manuscript. 2 ....
3. INFORM I want some (...) about tours in Spain. 3 ....
4. GRIEVE Bobby was filled with (.................................) when he saw the dead bird. 4 ....

5–13.

The three sentences of the paragraph below have been divided into sections and written in the wrong order. *The punctuation is correct.* Each line has a letter beside it. Decide the order in which the sections should be written to make the paragraph sensible. The letter of section F, which should come first, has been written in the box numbered 1. Write the letter of the section which should come second in the box numbered 2, and so on.

(A) by an optimistic bird-lover.
(B) then they will go away
(C) concerning the problem of
(D) A solution has been proposed
(E) and on historic buildings.
(F) Investigations have been carried out
(G) explains the problems to the pigeons,
(H) pigeons in public squares
(I) of their own accord.
(J) He suggests that if an official

1	F
2	
3	
4	
5	
6	
7	
8	
9	
10	

5 ....
6 ....
7 ....
8 ....
9 ....
10 ....
11 ....
12 ....
13 ....

GO STRAIGHT ON TO THE NEXT PAGE

TOTAL R W

Do not write in this column

READ this passage and then answer the questions that follow.

Surfing is a particularly thrilling pastime. It is dependent on skill to a great extent, but bad luck can mar the progress of even the most practised of professionals. The sport is, however, unsuitable for spectators. The ocean wave seldom consents to perform at its best within a mere 50 metres of the beach, and any occasion when it does is most unsatisfactory for the active participants. Yet spectators prefer these conditions as the human eye, even with assistance, can barely distinguish adequate outlines at distances greater than 50 metres, and finer points of technique are totally invisible.

14. Which of the following describes best what the passage is about? Underline it.

A life on the ocean wave / Sand and sea / An individual sport / English summer / Favourite sports 14 ....

15. Underline one word from inside the brackets which will complete this sentence sensibly.

To see real surfing it is necessary to go to the (mountains, seaside, snowfields, circus, swimming pool) 15 ....

16–19. Select the right words from the following list, and write them in the best spaces in the sentence below to complete a summary of the last three sentences of the passage. 16 ....

long, close, spectators, short, surfers, spectacles 17 ....

The..prefer the wave to break a........................distance 18 ....

from the beach but..prefer all the activity to be .... 19 ....

20. Which TWO of the words below are factors which, *according to the passage,* affect surfing? Underline them.

thrills, weather, skill, luck, assistance 20 ....

21. Which of the last EIGHT words of the passage can be omitted without changing the meaning of the whole sentence? .... 21 ....

Which word *in the passage* is used to mean:

22. exciting .... 22 ....

23. especially .... 23 ....

24. hardly .... 24 ....

25. experienced .... 25 ....

26. silhouettes .... 26 ....

TURN OVER AND GO STRAIGHT ON

TOTAL R

TOTAL W

Do not write in this column

27–33.
In each of the blanks below, put one of the phrases given you. Do not use any phrase more than once.

by Wednesday / of his childhood / with the picture / of rural scenes / for her part / in the country / for her pains / side by side.

Valerie was painting a picture which showed a man and a woman walking 27 ....

.... The scene was set .... 28 ....

Mr. Carr wanted the picture because it reminded him .... 29 ....

He asked Valerie to let him have the finished picture .... 30 ....

He thought Valerie was an able painter .... 31 ....

and .... Valerie enjoyed painting and took great 32 ....

care .... 33 ....

In the following sentences, write ONE word in the brackets which means the same, or nearly the same, as the words underlined. The first one has been done for you.

The *funny men at the circus* **(.....clowns.....) laughed, but were not really very happy.**

34. I gave my money to the man who sells bus-tickets (..) and he gave me a return to Broadway. 34 ....

35. Edward went to the local centre for lending books (..) hoping to find what he wanted. 35 ....

36. Mr. Hepplethwaite is a man who hoards all his money (..). 36 ....

37. They watched the ships disappear over the line where sea and sky meet (..). 37 ....

GO STRAIGHT ON TO THE NEXT PAGE

TOTAL	
R	
W	

(11)

Do not write in this column

38. The chess set was made from <u>material from elephants' tusks</u> (................................). 38 ....

39. The <u>twelve men called to decide the case</u> (..) were sworn in before the trial began. 39 ....

40. The batsman knocked down his <u>set of stumps and bails</u> (...) and was out. 40 ....

41. My dog is a <u>dog of unknown breed</u> (......................................); he has no pedigree. 41 ....

In the sentences below there are several blanks. Fill each of the blanks with suitable words so that the whole sentence makes sense. The first one has been done for you.

There are several different ways of getting **home,** but today we must take the **shortest.**

42. The motor bike .... but the rider was ....

....because he .... 42 ....

43. The seashore is ....because you never know........................

....you will ....when the tide is out. 43 ....

44. While the .... were running...

....Isobel ....reading a book. 44 ....

45. The young boy ....the labourer.................................

.......................the hedgerow.. his scythe. 45 ....

46. It is unusual... orchids...

in Great Britain ....in open country. 46 ....

TURN OVER AND GO STRAIGHT ON

TOTAL R

TOTAL W

(9)

Do not write in this colur

In the sentences below, write in the brackets *one* word which will *stand instead of* the word(s) underlined before the brackets. The first one is done for you.

He asked the girl (......her......) what she was doing.

47. Mr. Howard asked Timothy and me (..) to tea. | 47 ......

48. Arthur said to his friend, "Arthur (................................) won't buy you a birthday present if you don't behave." | 48 ......

49. Democracy is difficult to understand because democracy (..................................) is such a vague word. | 49 ......

50. Theresa said, "Your hat is pretty but I prefer Theresa's (..................................)." | 50 ......

51. The judge said that though the men were guilty the blame was not entirely the men's (..). | 51 ......

Here are several words or phrases, and opposite each one is a space to be filled with one word of the same meaning. Some of the letters are given to you. *Take care to spell the word correctly*. The first one is done for you.

man who bakes bread (b – r) ....baker..........

52. place where car is kept (g – e) .... | 52 ......

53. ten hundred (t – nd) .... | 53 ......

54. open-air meal (pi – c) .... | 54 ......

GO STRAIGHT ON TO THE NEXT PAGE

TOTAL R W

(8)

Do not write in this column

Do these the same way:

55. nearly (a — st) .... 55 ....

56. what girls tie in their hair (r — b — n) .... 56 ....

57. fear (fr — t) .... 57 ....

58. someone who is in the army (s — l — r) .... 58 ....

59. someone who writes books or plays or poems (a — t — r) .... 59 ....

In each question below there are two sentences. Join them together in any way you like so that you make *one* long, sensible sentence for each question. DO NOT USE "AND" OR "BUT". The first one is done for you.

They reached the city walls. They found the gates had been shut.

When they reached the city walls, they found the gates had been shut.

60. The bicycle will not go. The wheel is broken.

....

.... 60 ....

61. The engine stopped. There was no fuel.

....

.... 61 ....

62. The engine would not go. There was plenty of fuel.

....

.... 62 ....

63. You are ready. Your aunt will take you to the pictures.

....

.... 63 ....

64. The boys climbed up the cliff. They had found a sea-horse in a rock pool.

....

.... 64 ....

TURN OVER AND GO STRAIGHT ON

TOTAL	
R	
W	

(10)

Do no
write i
this colu

In the sentences below, put correct punctuation marks in the brackets. In each case, the punctuation mark will be one of the following:

. " " ? , !

65. Carol bought eggs ( ) bacon ( ) potatoes and mushrooms in the village ( ) 65 .....

66. Are you ready now ( ) I have been waiting a long time ( ) 66 .....

67. ( ) I am busy( ) ( ) said Roland ( ) 67 .....

68. Jane Grayson ( ) who goes to the same school as I do ( ) lives in the same road ( ) 68 .....

69. That's ridiculous ( ) You haven't got all that money, have you ( ) 69 .....

70. ( ) Delhi ( ) not Madras ( ) is the capital of India, ( ) said the teacher. 70 .....

Here is a sentence:

(a) The builder repaired the cottage.

Here is the same sentence expressed slightly differently:

(b) The cottage was repaired by the builder.

Do the same for all the sentences below, so that in each case sentence (b) has the same meaning as sentence (a).

71. (a) Nigel trapped the spy in front of the radio.

(b) The spy.. 71 .....

72. (a) The expert had not taught the skater for very long.

(b) The skater.. 72 .....

73. (a) The meal was already being served by the maid.

(b) The maid .... 73 .....

74. (a) The lion will attack the trainer.

(b) The trainer... 74 .....

75. (a) The hardest task is being done by voluntary workers.

(b) Voluntary workers.. 75 .....

END OF TEST

LOOK OVER YOUR WORK UNTIL TIME IS UP

TOTAL R W

(11

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APPENDIX (iii)

NATIONAL FOUNDATION FOR EDUCATIONAL RESEARCH IN ENGLAND AND WALES

Test 263

MATHEMATICS ATTAINMENT TEST EF

DO NOT turn over

OR open this booklet until you are told to do so

Read these instructions carefully:

All of the questions in this test should be answered on the answer sheet, **not in the test booklet.** You may work out your answers on the blank sheet of paper, but always **mark your answers on the answer sheet.** After each question, there are five alternative answers and each has its own letter. Find out which is the right answer and then **blacken the space below the letter which goes with the right answer.**

Here is an example:

P.1 What is 8×3?

(a) 21 (b) 22 (c) 23 (d) 24 (e) 25

$8 \times 3 = 24$, so the correct answer is (d). On the answer sheet, blacken the space below the letter (d), like this:

P. 1	a	b	c	d	e
	○	○	○	●	○

In some cases, three or more questions share the same alternative answers. Just do these in exactly the same way. Here are some more examples. Do them yourself, and mark the answers on the answer sheet, opposite numbers P.2 to P.6.

What is:

P.2	3×4?	(a) 24
P.3	4×5?	(b) 20
P.4	$14 + 6$?	(c) 16
P.5	$32 \div 2$?	(d) 12
P.6	$8 - 4$?	(e) none of these

Here are the answers.

	a	b	c	d	e
2	○	○	○	●	○
3	○	●	○	○	○
4	○	●	○	○	○
5	○	○	●	○	○
6	○	○	○	○	●

2 $3 \times 4 = 12$, so the answer is (d)

3 $4 \times 5 = 20$, so the answer is (b)

4 $14 + 6 = 20$, so the answer is (b)

5 $32 \div 2 = 16$, so the answer is (c)

6 $8 - 4 = 4$, so the answer is (e).

otice that the same answer may be the correct answer more than once. Thus (b) is the rrect answer to P.3 and P.4.

otice also that the answer to P.6 is 4, which is not in the list of alternatives. The correct swer is therefore "(e) none of these", meaning that none of the answers (a) to (d) is correct.

nere is **always one and never more than one correct answer** in the set of alternative answers r each question.

ways make sure that the question number on the answer sheet is the same as the question number the test.

you should wish to alter an answer, rub out the mark **completely** and then mark your new answer **early.**

hen you are told to stop, STOP WORKING AT ONCE.

SK NO QUESTIONS AT ALL, ONCE YOU HAVE BEEN TOLD TO START.

<u>You may find this information useful.</u>

"Square centimetres" is also written as cm^2
"Cubic centimetres" is also written as cm^3

10 millimetres (mm)	= 1 centimetre (cm)
100 centimetres	= 1 metre (m)
1000 metres	= 1 kilometre (km)
1000 grams (g)	= 1 kilogram (kg)

you have any questions ask them now.

DO NOT TURN OVER UNTIL YOU ARE TOLD

1. What is the largest whole number that can be made from the digits 1, 6, 3, 2 if all the digits are to be used?

(a) 6321 (b) 3621 (c) 2163 (d) 1623 (e) 1236

2–3. Which of the following shapes best describe these common things?

(a) a rectangle (b) a square (c) a triangle (d) a circle (e) a rhombus

2. A gramophone record

3. A tennis court

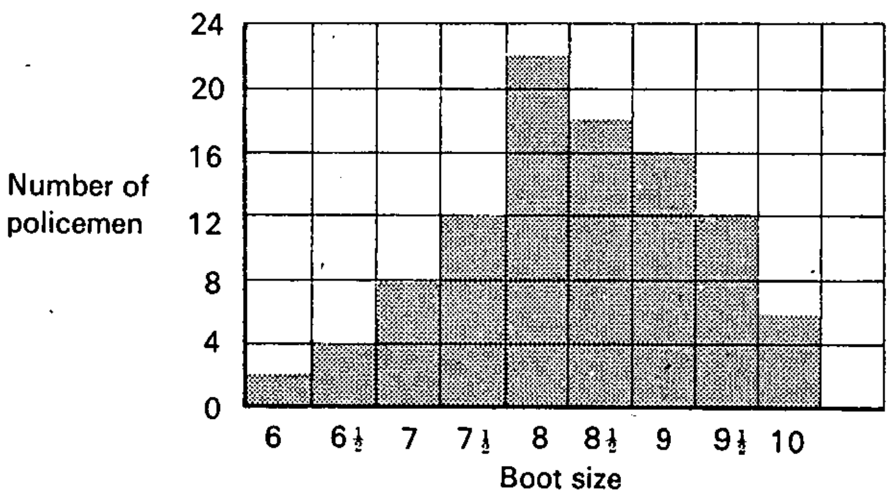
---

4. In this addition one figure was replaced by * wherever it appeared. What does * stand for?

```
  1*
  *1
+ **
----
 165
```

(a) 2 (b) 3 (c) 5 (d) 7 (e) 8

5–7. The bar chart below shows how many policemen wear boots in each of the sizes from 6 to 1



5. How many policemen wear a size 9 boot or larger?

(a) 16 (b) 20 (c) 25 (d) 30 (e) 34

6. Which two sizes of boots are worn by the same number of policemen?

(a) 6 and 6½ (b) 6½ and 10 (c) 7½ and 9½ (d) 8½ and 9 (e) 8½ and 9½

7. Which size of boot is worn by most policemen?

(a) 6 (b) 7 (c) 8 (d) 9 (e) 10

GO ON TO THE NEXT PAGE

A boy thinks of a number, doubles it and adds two. If the number he thinks of is x, what is the final number?

(a) $x + 4$ (b) $2x + 2$ (c) $2x + 3$ (d) $2x + 4$ (e) none of these

---

A man walks round the perimeter of a rectangular field. Which of the following describes his action?

(a) walks along one side of the field

(b) walks half way round the field

(c) walks along both shorter sides of the field

(d) walks diagonally from corner to corner of the field

(e) walks along all sides of the field

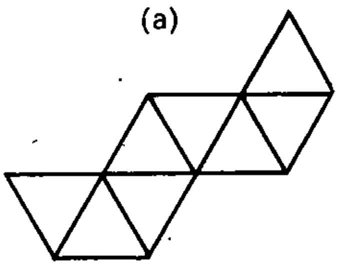
–12. Which of these nets could be used to make the following solids?

. Cylinder

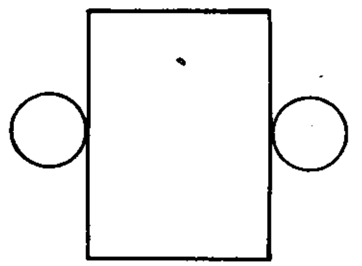
. Pyramid

. Cone

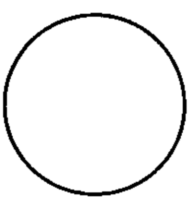
(a)



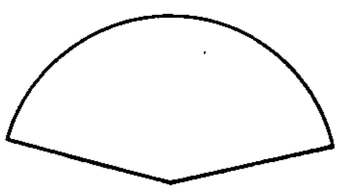
(b)



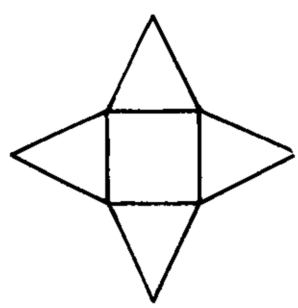
(c)



(d)



(e)



. If an odd number is multiplied by an even number, the answer will be:

(a) always an odd number

(b) usually an odd number

(c) an odd number half of the time

(d) usually an even number

(e) always an even number

GO ON TO THE NEXT PAGE

14–16. To which decimal is each of the following percentages equal ?

	Percentages	Decimals
14.	5%	(a) 0·005
15.	50%	(b) 0·03
		(c) 0·05
16.	30%	(d) 0·30
		(e) 0·50

---

17. Of the 360 men and women at a party, one third were women. How many men wer present ?

(a) 60 (b) 120 (c) 240 (d) 1080 (e) 2160

18–19. What are the results of doing the following operations on the number 6 ?

18.	Adding -5	(a) 1
		(b) 4
19.	Subtracting $+2$	(c) 8
		(d) 9
		(e) 11

20–22. To which of the answers (a) to (e) is each of the statements 20, 21 and 22 equivalent ?

20.	2 out of 6	(a) 1
21.	19 out of 19	(b) $\frac{5}{9}$
22.	10 out of 18	(c) $\frac{1}{3}$
		(d) $\frac{1}{19}$
		(e) $\frac{1}{2}$

---

23. If $B = A$ and $3A + 2B = 10$

What are the values of A and B ?

(a) $A = 2$ and $B = 2$

(b) $A = 3$ and $B = 3$

(c) $A = 4$ and $B = 4$

(d) $A = 5$ and $B = 5$

(e) $A = 10$ and $B = 10$

GO ON TO THE NEXT PAGE

24. The square of a number is always:

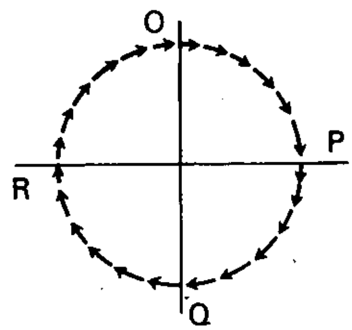
(a) the number added to itself
(b) the number multiplied by itself
(c) the number plus 2
(d) the number multiplied by 2
(e) none of these

25–26. The population of a town is 74 938. What is the population to the nearest:

25. ten?
26. hundred?

(a) 75 000
(b) 74 950
(c) 74 940
(d) 74 930
(e) 74 900

27–29.



An aircraft flies clockwise in a circle from O. Where will it be if it turns through:

27. 180°
28. 270°
29. 660°

(a) O
(b) P
(c) Q
(d) R
(e) none of these

---

30. Which of the following fractions is the smallest?

(a) $\frac{11}{12}$ (b) $\frac{5}{6}$ (c) $\frac{3}{8}$ (d) $\frac{1}{9}$ (e) $\frac{1}{4}$

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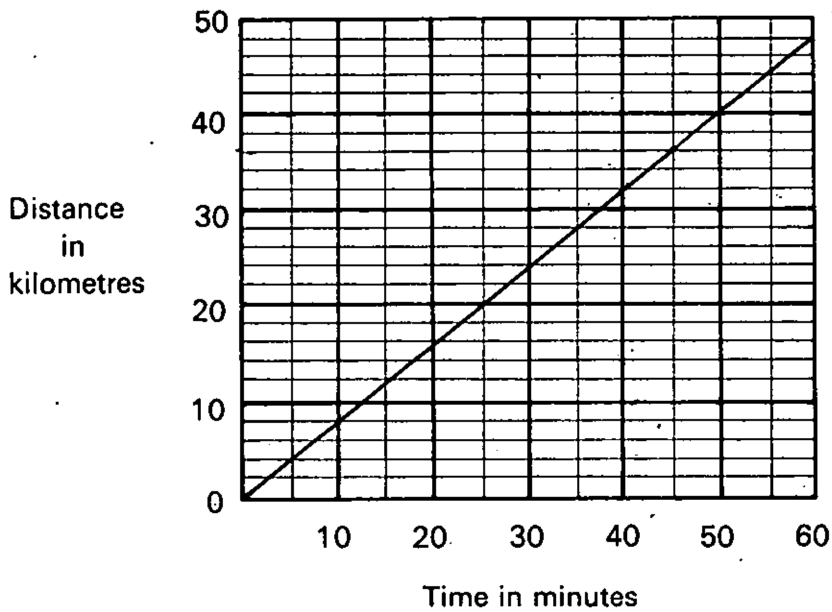
31–33.

The following table shows the time taken by a car to travel various distances at the same speed.

Time in minutes	0	15	25	30	55
Distance in kilometres	0	12	20	24	44

This information is plotted on the axes below, in the form of a straight line graph.



31. How far has the car gone in 45 minutes?

(a) 32 km (b) 36 km (c) 40 km (d) 44 km (e) 48 km

32. How long does it take the car to travel 40 kilometres?

(a) 50 min (b) 45 min (c) 40 min (d) 35 min (e) 30 min

33. What is the speed of the car, in kilometres per hour?

(a) 75 (b) 48 (c) 43 (d) 38 (e) 30

---

34. The square root of 90 lies between:

(a) 2 and 4
(b) 5 and 7
(c) 8 and 10
(d) 11 and 20
(e) 21 and 40

---

35. It costs 40 centimes to send a postcard from France to England.

How much does it cost to send 9 postcards? (100 Centimes = 1 Franc)

(a) 3·06 Fr (b) 3·60 Fr (c) 30·6 Fr (d) 36·0 Fr (e) 306 Fr

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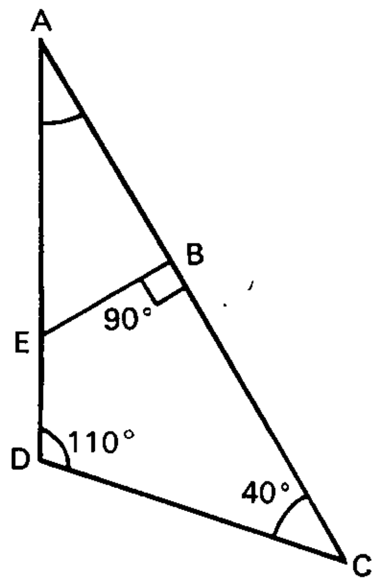
36–37. Use the sketch below to answer the following:



36. How big is angle BED?

(a) 90° (b) 100° (c) 110° (d) 120° (e) 130°

37. How big is angle BAE?

(a) 70° (b) 60° (c) 50° (d) 40° (e) 30°

38–40. To which of the following fractions is each of the decimals equivalent?

	Decimals	Fractions
38.	0·60	(a) $\frac{9}{25}$
39.	0·45	(b) $\frac{4}{15}$
40.	0·36	(c) $\frac{4}{9}$
		(d) $\frac{3}{5}$
		(e) $\frac{9}{20}$

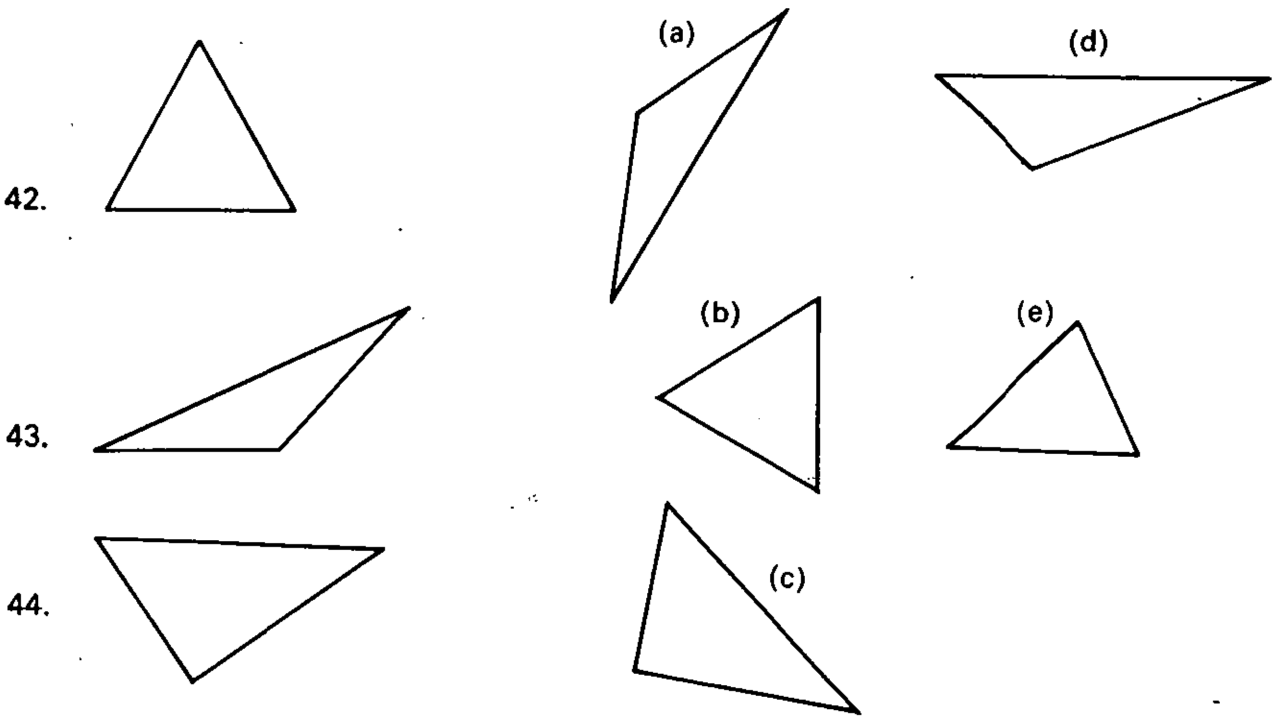
---

41. Which of the following has the same value as 3^3?

(a) 3×3 (b) $3 + 3$ (c) $3 + 3 + 3$ (d) $3 \div 3$ (e) $3 \times 3 \times 3$

GO ON TO THE NEXT PAGE

42–44. To which of the triangles (a) to (e) is each of the triangles 42, 43 and 44 **similar**?



45–46. A pile of sand weighing 2·520 kg is divided successively into 2, 3, 4, 5, 6, 7, ,8, 9, and 10 equal smaller piles. The table below shows the weight of these piles.

Number of small piles	1	2	3	4	5	6	7	8	9	10
Weight of each pile in grams (g)	2 520	1 260	840	630	504	420	360	315	280	252

How many piles would there be if each pile weighed:

45. 180 g?

46. 42 g?

(a) 14
(b) 40
(c) 60
(d) 280
(e) 420

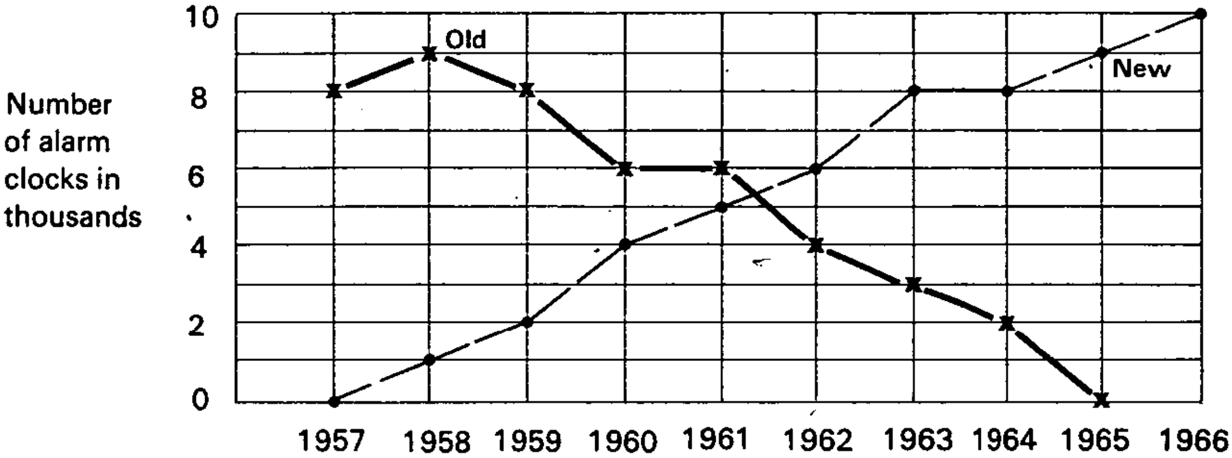
---

47. Some time ago it was said that an average family had 2·4 children.
What does this mean?

(a) all families had 2·4 children
(b) all families had either 2 or 3 children
(c) some families had a child for only 0·4 of the time
(d) the total number of children was 2·4 times the total number of families.
(e) the average was wrongly calculated

GO ON TO THE NEXT PAGE

48–49. The graph below shows the number of one manufacturer's old and new alarm clocks in use during each year from 1957 to 1966.



48. What was the largest number of old clocks in use during any one year during this period?

(a) 10 000 (b) 9 000 (c) 8 000 (d) 7 000 (e) 6 000

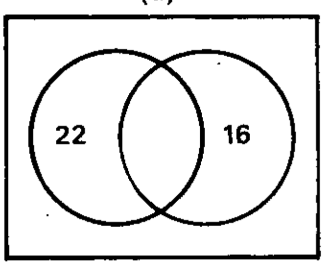
49. How many clocks (old and new) were in use in 1963?

(a) 7 000 (b) 8 000 (c) 9 000 (d) 10 000 (e) 11 000

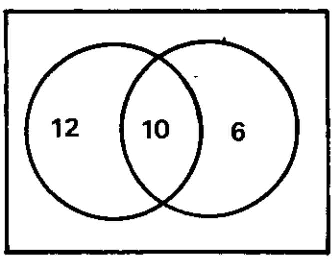
50–51. In a class of children, 22 liked apples, 16 liked oranges, and of these, 10 liked both apples and oranges.

50. Which one of the following Venn diagrams illustrates these facts?

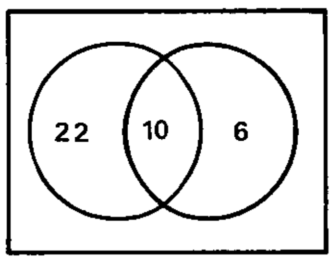
(a)



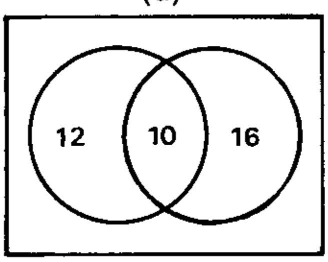
(b)



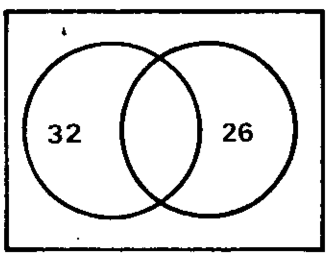
(c)



(d)



(e)

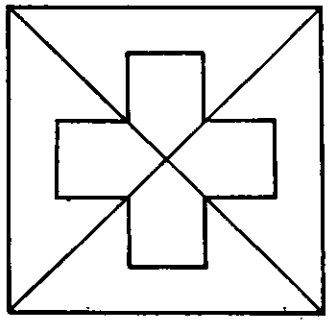


51. There were 35 children altogether in the class. How many did not like apples or oranges?

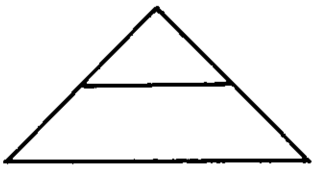
(a) 7 (b) 10 (c) 13 (d) 19 (e) 21

GO ON TO THE NEXT PAGE

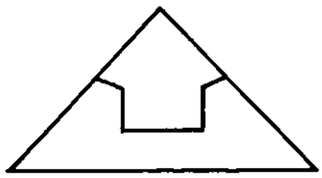
52. Which one of the shapes below could be used four times to make this diagram?



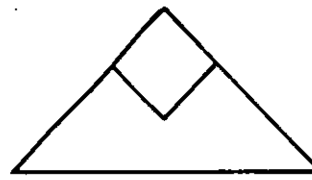
(a)



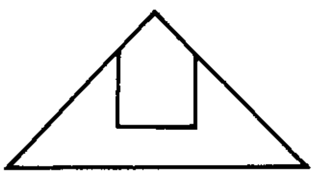
(b)



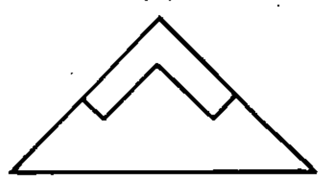
(c)



(d)



(e)



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53. Which one of these statements best conveys the idea of the volume of an object?

(a) the amount of space filled by an object
(b) the weight of an object
(c) the surface area of an object
(d) the weight of water an object will hold
(e) all of these

---

54. Which one of the following numbers has 7 as a factor?

(a) 51 (b) 61 (c) 71 (d) 81 (e) 91

---

55. A man photographed two trees, both the same distance from the camera. The trees on the photograph were 3 cm and 4 cm high. If the height of the smaller tree is in fact 12 metres, what is the height of the other tree?

(a) 14 m (b) 15 m (c) 16 m (d) 18 m (e) 24 m

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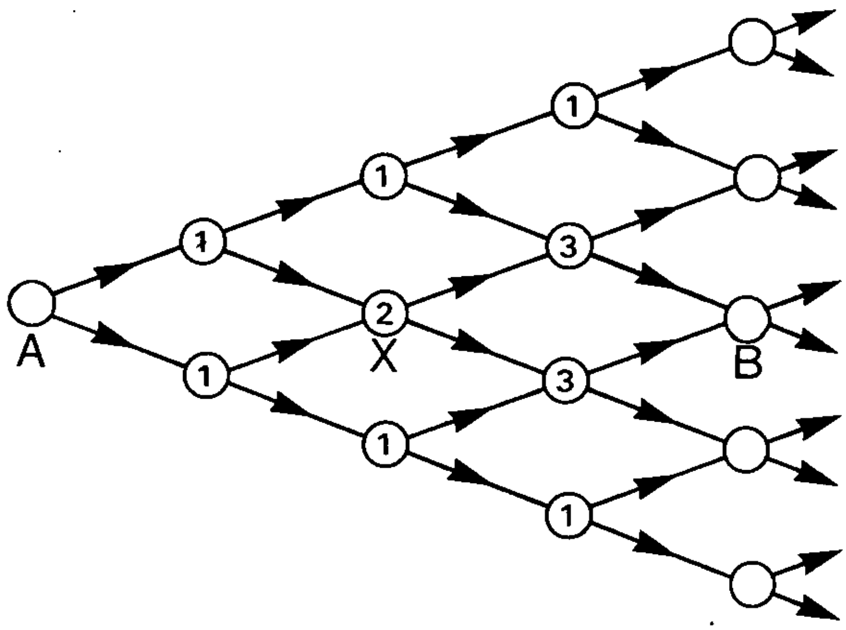
56–57. The diagram below shows the number of routes for getting to various parts of the diagram starting at A and going **only in the direction of the arrows.**



56. How many routes are there for getting from A to B ?

(a) 4 (b) 5 (c) 6 (d) 7 (e) 8

57. On how many of these routes do you pass through X ?

(a) 4 (b) 5 (c) 6 (d) 7 (e) 8

---

58. The population of a city is given as approximately 2 400 000. Which one of the following figures has been rounded off ?

(a) 2 040 950

(b) 2 114 158

(c) 2 240 876

(d) 2 446 314

(e) 2 475 912

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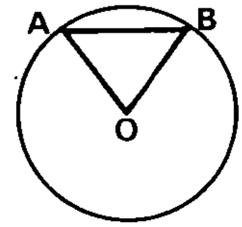
59. O is the centre of the circle.
AB is equal in length to the radius of the circle.
What is angle AOB ?



(a) 30° (b) 60° (c) 75° (d) 90° (e) you can't tell

---

60. The length of one side of a square is y cm. What is the **area** of the square?
(a) 2y cm^2 (b) 3y cm^2 (c) 4y cm^2 (d) y^2 cm^2 (e) $4y^2$ cm^2

END OF TEST

APPENDIX (iv)

PERCENTAGE DIFFERENCE BETWEEN THE SEXES AND THE SIGNIFICANCE LEVELS FOR THE ITEMS IN MATHEMATICS TESTS DE1 AND EF.

ITEM	DIFFERENCE %	BOYS OR GIRLS AHEAD	TWO STANDARD DEVIATIONS	SIGNIFICANT
1.1	8.3	G	9.2	NO
1.2	6.3	B	11.4	NO
1.3	3.0	B	13.7	NO
1.4	7.6	G	14.8	NO
1.5	1.9	G	15.4	NO
1.6	5.1	B	15.5	NO
1.7	15.7	B	15.4	YES
1.8	2.3	G	15.1	NO
1.9	0.5	G	15.5	NO
1.10	4.3	G	7.2	NO
1.11	11.0	G	9.7	YES
1.12	5.8	B	12.3	NO
1.13	3.7	B	11.8	NO
1.14	12.3	B	15.0	NO
1.15	2.4	G	15.5	NO
1.16	0.1	B	15.1	NO
1.17	14.4	B	15.3	NO
1.18	3.1	G	14.9	NO
1.19	12.9	B	15.2	NO
1.20	5.8	G	15.1	NO
1.21	19.4	B	14.1	YES
1.22	0.1	B	15.6	NO
1.23	4.5	G	15.5	NO
1.24	7.7	B	15.5	NO
1.25	4.2	B	15.6	NO
1.26	14.6	B	14.8	NO
1.27	11.4	G	15.1	NO
1.28	0.7	B	15.6	NO
1.29	0.7	B	15.1	NO
1.30	17.7	B	12.1	YES
1.31	5.9	B	15.5	NO
1.32	1.8	B	14.2	NO
1.33	1.5	G	15.5	NO
1.34	8.9	B	15.3	NO

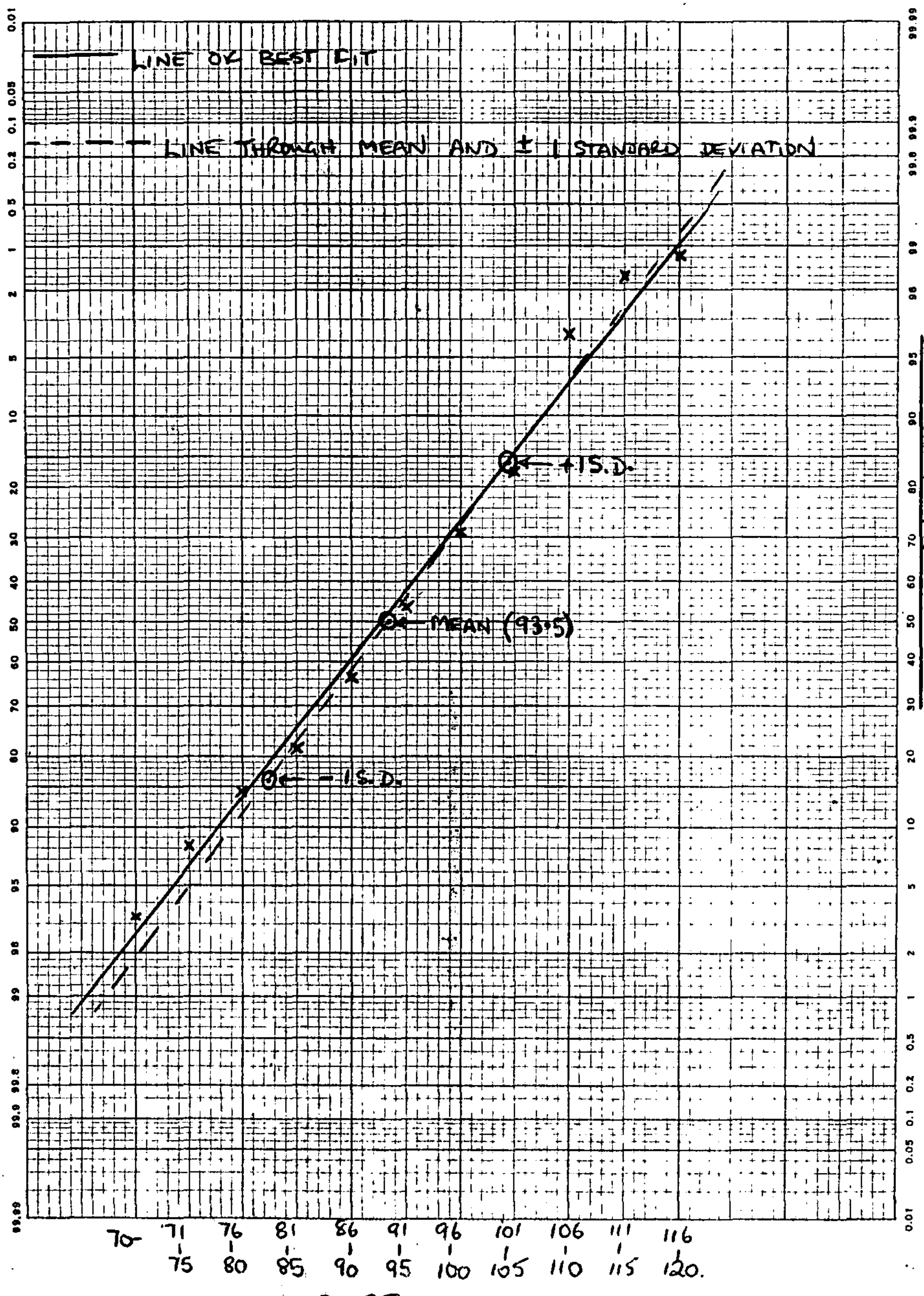
ITEM	DIFFERENCE %	BOYS OR GIRLS AHEAD	TWO STANDARD DEVIATIONS	SIGNIFICANT
1.35	9.2	B	14.1	NO
1.36	0.1	G	15.1	NO
1.37	14.2	B	14.0	YES
1.38	5.0	G	15.6	NO
2.1	2.8	B	10.2	NO
2.2	10.0	B	13.1	NO
2.3	8.1	B	14.7	NO
2.4	5.8	G	15.5	NO
2.5	1.3	B	15.5	NO
2.6	5.0	G	10.9	NO
2.7	5.4	G	7.9	NO
2.8	2.8	G	15.3	NO
2.9	1.6	G	13.2	NO
2.10	0.2	G	15.6	NO
2.11	11.3	G	14.5	NO
2.12	10.5	G	14.5	NO
2.13	0.3	G	15.5	NO
2.14	4.9	B	14.8	NO
2.15	4.1	G	13.3	NO
2.16	4.7	G	13.0	NO
2.17	13.1	B	15.3	NO
2.18	2.7	B	14.5	NO
2.19	4.5	G	15.5	NO
2.20	1.8	G	14.1	NO
2.21	1.8	G	14.2	NO
2.22	11.4	B	14.9	NO
2.23	9.1	B	15.4	NO
2.24	6.4	G	15.5	NO
2.25	3.1	B	15.6	NO
2.26	10.0	B	15.1	NO
2.27	8.8	B	15.2	NO
2.28	8.6	B	15.5	NO
2.29	9.8	B	15.5	NO
2.30	23.0	B	14.6	YES
2.31	9.0	B	15.1	NO
2.32	8.8	B	14.8	NO
2.33	0.3	G	15.6	NO

ITEM	DIFFERENCE %	BOYS OR GIRLS AHEAD	TWO STANDARD DEVIATIONS	SIGNIFICANT
2.34	8.9	B	15.3	NO
2.35	3.0	B	14.3	NO
2.36	2.2	G	12.7	NO
2.37	0.7	G	13.4	NO
2.38	19.2	B	14.5	YES
2.39	12.6	B	12.1	YES
2.40	6.5	B	13.2	NO
2.41	1.2	G	15.3	NO
2.42	3.3	G	10.9	NO
2.43	4.0	G	13.1	NO
2.44	7.2	G	11.8	NO
2.45	2.4	G	15.2	NO

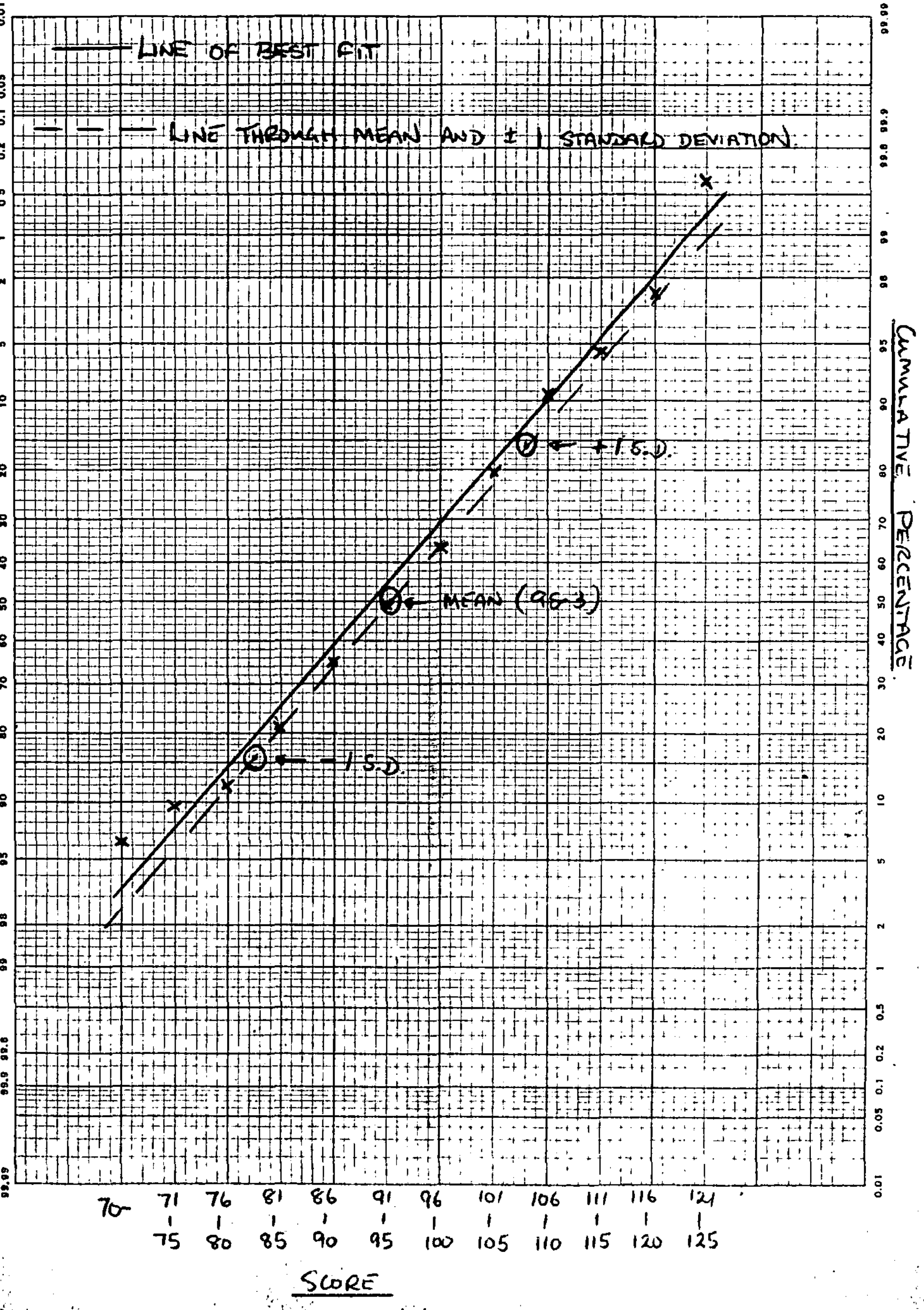
APPENDIX (v)

GRAPHS OF THE RESULTS

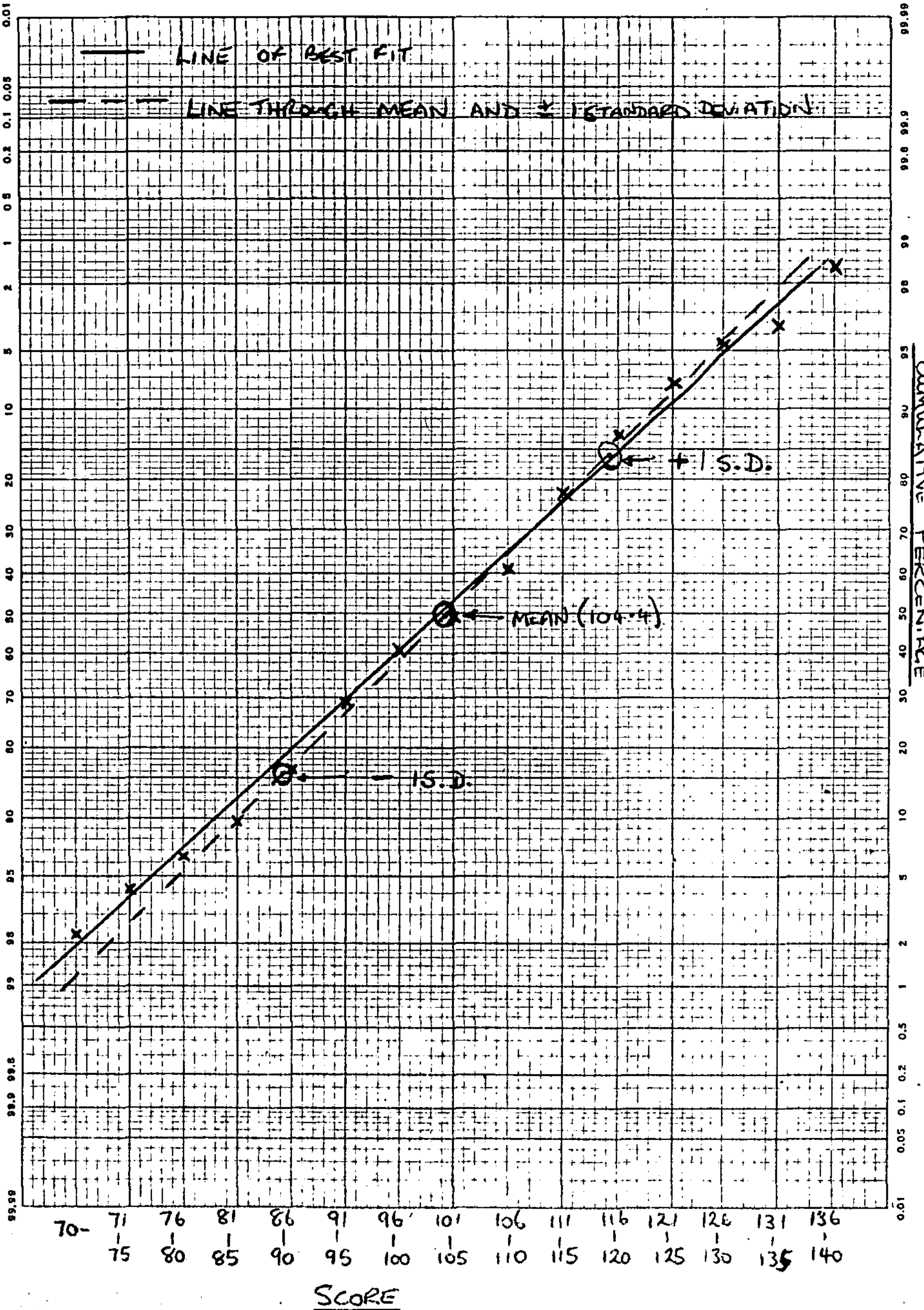
CUMULATIVE PERCENTAGE CURVE FOR MATHEMATICS TEST DE1, PLOTTED ON NORMAL PROBABILITY PAPER



CUMULATIVE PERCENTAGE CURVE FOR ENGLISH TEST D2, PLOTTED ON NORMAL PROBABILITY PAPER



CUMULATIVE PERCENTAGE CURVE FOR MATHEMATICS TEST
EF PLOTTED ON NORMAL PROBABILITY PAPER



CORRELATION BETWEEN GIRLS' SCORES ON MATHS TEST DE1 (X) AND MATHS TEST EF (Y)

X (MARK ON TEST DE1 – GIRLS)

Y (MARK ON TEST EF – GIRLS)

Y \ X	70-	71-75	76-80	81-85	86-90	91-95	96-100	101-105	106-110	111-115	116-20	f	y'	fy'	$\Sigma x'$	$\Sigma x'y'$	fy'^2
136-140											I	1	7	7	5	25	49
131-135														–			
126-130								I	II	I		4	5	20	12	60	100
121-125							I	III	III			7	4	28	16	64	112
116-120							卌I	II	卌			12	3	36	24	72	108
111-115				I		III	IIII	卌 IIII	II			19	2	38	26	52	76
106-110				I	I	IIII	卌 II	I	I			15	1	15	9	9	15
101-105				I	III	卌	III					12	0	0	-2	0	0
96-100				卌	II	卌 II	III	I				18	-1	-18	-7	7	18
91-95			卌 II	III	卌	卌						20	-2	-40	-32	64	80
86-90		II	I	I	IIII	IIII						12	-3	-36	-17	51	108
81-85	I	I	I		III							6	-4	-24	-15	60	96
76-80	I		II		I							4	-5	-20	-12	60	100
71-75		I										1	-6	-6	-4	24	36
70-		I										1	-7	-7	-4	28	49
												132		-7	-1	586	947

f	2	5	11	12	19	28	23	17	13	1	1	132
x'	-5	-4	-3	-2	-1	0	1	2	3	4	5	
fx'	-10	-20	-33	-24	-19	0	23	34	39	4	5	-1
$\Sigma y'$	-9	-23	-31	-11	-40	-19	31	41	42	5	7	-7
$\Sigma x'y'$	45	92	93	22	40	0	31	82	126	20	35	586
fx'^2	50	80	99	48	19	0	23	68	117	16	25	545

$r = 0.82$

CORRELATION BETWEEN BOYS' SCORES ON MATHS TEST DE1 (X) AND MATHS TEST EF (Y)

X – (MARK ON TEST DE1 – BOYS)

Y (MARK ON TEST EF – BOYS)

Y \ X	70-	71-75	76-80	81-85	86-90	91-95	96-100	101-105	106-110	111-115	116-120	121-125	f	y'	fy'	$\Sigma x'$	$\Sigma x'y'$	fy'^2
140+										I		II	3	6	18	13	78	108
136-140								I	I	II			4	5	20	9	45	100
131-135								I	II				3	4	12	5	20	48
126-130								I	II				3	3	9	5	15	27
121-125								II	IIII				6	2	12	10	20	24
116-120						I	III	IIII	III				11	1	11	9	9	11
111-115					II	III	卌 IIII	IIII	III	I			22	0	0	6	0	0
106-110					I	卌 I	IIII	III					14	-1	-14	-5	5	14
101-105			I	I	II	II	II	I					9	-2	-18	-12	24	36
96-100				II	卌	III							10	-3	-30	-19	57	90
91-95		卌	I		III		I						10	-4	-40	-35	140	160
86-90			I	I	II								4	-5	-20	-11	55	100
81-85	I			I									2	-6	-12	-9	54	72
76-80		I			I								2	-7	-14	-7	49	98
71-75	II	I	I										4	-8	-32	-21	168	256
70-	III			I									4	-9	-36	-21	189	364
													111		-134	-83	928	1510.

	70-	71-75	76-80	81-85	86-90	91-95	96-100	101-105	106-110	111-115	116-120	121-125	
f	6	7	4	6	16	15	19	17	15	4	0	2	111
x'	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	
fx'	-36	-35	-16	-18	-32	-15	0	17	30	12	0	10	-83
$\Sigma y'$	-49	-35	-19	-28	-49	-18	-9	15	30	16	0	12	-134
$\Sigma x'y'$	294	175	76	84	98	18	0	15	60	48	0	60	928
fx'^2	216	175	64	54	64	15	0	17	60	36	0	50	751

$r = 0.86$

CORRELATION BETWEEN GIRLS' SCORES ON MATHS TEST DE1 (X) AND ENGLISH TEST D2 (Y)

X (MARK ON MATHS TEST DE1 - GIRLS)

Y (MARK ON TEST D2-GIRLS)

Y \ X	70-	71-75	76-80	81-85	86-90	91-95	96-100	101-105	106-110	111-115	116-120
126-130									I		
121-125								I	II	I	I
116-120							II		I		
111-115					I		I	III	III		
106-110				I		III	IIII	卌			
101-105				I		卌	卌 II	III	IIII		
96-100			I	II	II	IIII	III	II	II		
91-95				I	III	卌 III	卌	III			
86-90		I	III	IIII	卌 I	卌 III	I				
81-85	I		III	II	卌						
76-80		II	I	I	I						
71-75	I		I								
70-		II	II		I						

f	y'	fy'	Σx'	Σx'y'	fy'^2
1	6	6	3	18	36
5	5	25	17	85	125
3	4	12	5	20	48
8	3	24	15	45	72
13	2	26	12	24	52
20	1	20	23	23	20
16	0	0	4	0	0
20	-1	-20	6	-6	20
23	-2	-46	-26	52	92
11	-3	-33	-23	69	33
5	-4	-20	-14	56	80
2	-5	-10	-8	40	50
5	-6	-30	-15	90	180
132		-46	-1	516	808

f	2	5	11	12	19	28	23	17	13	1	1	132
x'	-5	-4	-3	-2	-1	0	1	2	3	4	5	
fx'	-10	-20	-33	-24	-19	0	23	34	39	4	5	-1
$\Sigma y'$	-8	-22	-36	-16	-37	-15	19	24	33	5	5	46
$\Sigma x'y'$	40	88	108	32	37	0	19	48	99	20	25	516
fx'^2	50	80	99	48	19	0	23	68	117	16	25	545

$r = 0.79$

CORRELATION BETWEEN BOYS' SCORES ON MATHS TEST DE 1 (X) AND ENGLISH TEST D2 (Y)

X (MARK ON TEST DE 1 - BOYS)

Y (MARK ON TEST D2 - BOYS)

Y \ X	70-	71-75	76-80	81-85	86-90	91-95	96-100	101-105	106-110	111-115	116-120	121-125	f	y'	fy'	$\Sigma x'$	$\Sigma x'y'$	fy'^2
116-120						II			I	I		I	5	5	25	8	40	125
111-115							I						1	4	4	0	0	16
106-110					II	I	III	III	IIII				13	3	39	6	18	117
101-105					I	IIII	II	卌 I	IIII	II		I	20	2	40	19	38	80
96-100					III	III	IIII	卌 I	III	I			20	1	20	6	6	20
91-95		I			III	II	卌		I				12	0	0	-11	0	0
86-90					II	III	III	II	II				12	-1	-12	-1	1	12
81-85	I	II		卌	III								11	-2	-22	-37	74	44
76-80													0	-3	0	0	0	0
71-75		I	III	I	I		I						7	-4	-28	-22	88	112
70-	卌	III	I		I								10	-5	-50	-51	255	250
													111		16	-83	520	776

f	6	7	4	6	16	15	19	17	15	4	0	2	111
x'	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	
fx'	-36	-35	-16	-18	-32	-15	0	17	30	12	0	10	-83
$\Sigma y'$	-27	-23	-17	-14	-6	21	14	25	26	10	0	7	16
$\Sigma x'y'$	162	115	68	42	12	21	0	25	52	30	0	35	520
fx'^2	216	175	64	54	64	15	0	17	60	36	0	50	751

$$\underline{\underline{r = 0.73}}$$

CORRELATION BETWEEN GIRLS' SCORES ON ENGLISH TEST D2 (X) AND MATHS TEST EF (Y)

X (MARK ON TEST D2 - GIRLS).

	70-	71-75	76-80	81-85	86-90	91-95	96-100	101-105	106-110	111-115	116-120	121-125	126-130
136-140												I	
131-135													
126-130									I		I	I	I
121-125							I	III		II			
116-120								卌 II	I	II	I	I	
111-115						III	卌 I	III	卌	I		I	
106-110					III	III	II	III	II	III		I	
101-105					II	III	II	II	II	I			
96-100			I	I	II	卌 II	III	II	I		I		
91-95	I		I	卌	卌 III	I	II	I	I				
86-90			III	II	卌	I	I						
81-85	I	I		I	III								
76-80	I	I		II									
71-75	I												
70-	I												

f	y'	fy'	$\Sigma x'$	$\Sigma x'y'$	fy'^2
1	7	7	5	35	49
0	6	0	0	0	0
4	5	20	17	85	100
6	4	24	9	36	96
12	3	36	24	72	96
19	2	38	18	36	76
17	1	17	12	12	17
12	0	0	2	0	0
18	-1	-18	-10	10	18
20	-2	-40	-39	78	80
12	-3	-36	-29	87	108
6	-4	-24	-20	80	96
4	-5	-20	-17	85	100
1	-6	-6	-6	36	36
1	-7	-7	-6	42	49
132		-9	-40	694	829

f	5	2	5	11	23	18	17	21	13	9	3	5	1	132
x'	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	-
fx'	-30	-10	-20	-33	-46	-18	0	21	26	27	12	25	6	-40
$\Sigma y'$	-24	-9	-12	-31	-42	-3	8	38	17	19	7	18	5	-9
$\Sigma x'y'$	144	45	48	93	84	3	0	38	34	57	28	90	30	694
fx'^2	180	50	80	99	92	18	0	21	52	81	48	125	36	882

$r = 0.81$

CORRELATION BETWEEN BOYS' SCORES ON ENGLISH TEST D2 (X) AND MATHS TEST EF (Y)

X (MARK ON TEST D2 - BOYS)

Y (MARK ON TEST EF - BOYS)

Y \ X	70-	71-75	76-80	81-85	86-90	91-95	96-100	101-105	106-110	111-115	116-120	f	y'	fy'	$\Sigma x'$	$\Sigma x'y'$	fy'^2
140+								I			II	3	7	21	12	84	147
136-140							I	II	I			4	6	24	8	48	144
131-135								I	I		I	3	5	15	10	50	75
126-130							I		II			3	4	12	7	28	48
121-125					II	I	II		I			6	3	18	3	9	54
116-120						I	II	~~IIII~~ I	II			11	2	22	20	40	44
111-115					II	IIII	~~IIII~~ I	III	IIII 4		II	21	1	21	35	35	21
106-110					III	II	~~IIII~~	III		I		14	0	0	12	0	0
101-105		I		I	I	II	I	II				8	-1	-8	-2	2	8
96-100	I	I		III	I	I	II	I	I			11	-2	-22	-9	18	44
91-95	I	IIII		III	I	I						10	-3	-30	-28	84	90
86-90	I			I		I		I				4	-4	-16	-5	20	64
81-85				II								2	-5	-10	-4	20	50
76-80	I				I							2	-6	-12	-6	36	72
71-75	III	I										4	-7	-28	-19	133	196
70-	III			I								4	-8	-32	-17	136	256
												111		-18	47	737	1303

	70-	71-75	76-80	81-85	86-90	91-95	96-100	101-105	106-110	111-115	116-120	
f	10	7	0	11	11	13	20	20	13	1	5	111
x'	-5	-4	-3	-2	-1	0	1	2	3	4	5	
fx'	-50	-28	0	-22	-11	0	20	40	39	4	25	17
$\Sigma y'$	-60	-22	0	-38	4	-2	21	29	29	0	21	-18
$\Sigma x'y'$	300	88	0	76	-4	0	21	58	87	0	105	737
fx'^2	250	112	0	44	11	0	20	80	117	16	125	775

$$r = 0.74$$