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SEX-RELATED DIFFERENCES IN MATHEMATICS ACHIEVEMENT SCORES IN GRADE 4 AND GRADE 8 IN KERALA, INDIA

By

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ABSTRACT

The purpose of this study was to investigate whether sex-related differences in mathematics achievement scores existed in a sample from the under-developed world; and if so, what bearing the findings had on the current "nature" and "nurture" positions on such differences. A total of 1377 students at two grade levels, Grade 4 and Grade 8, drawn from three districts in the state of Kerala, India, were tested. Items for the instruments of testing were drawn from the British Columbia Learning Assessment Study in Mathematics of 1981 for the Grade 4 level and from the Second International Mathematics Study conducted in British Columbia in 1982 for the Grade 8 level.

The results showed that sex-related differences in mathematics achievement scores existed at the two grade levels in varying degrees depending on the urban-rural location of the sample, and not consistently in favour of the same sex. In the urban sample, boys outperformed girls by 7% at the Grade 4 level and girls outperformed boys by 3% at the Grade 8 level. In the rural sample, girls outperformed boys by 2% at the Grade 4 level and boys outperformed girls by 8% at the Grade 8 level.

Based on the results of this study, it is hypothesized that if the "nature-position" of genetic male superiority in mathematical ability is the reason for the instances of superior

male scores in this study, data at the same grade levels that show marginally superior female achievement scores in a different locale indicate that "nurture" of some sort can likely remedy any deficiencies in mathematical ability that may be imposed by "nature".

Research Supervisor: Dr. D. F. Robitaille.

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Chapter 1

INTRODUCTION

There is a consensus in educational research that males outperform females on school mathematics achievement tests. While theories of male intellectual superiority have not been lacking through history, the earliest evidence of extensive research data came with the First International Mathematics Study conducted across twelve countries by the International Association for the Evaluation of Educational Achievement (IEA), in 1964.

A limited pilot project conducted as a forerunner to this study in Belgium, England, Finland, France, Germany, Israel, Poland, Scotland, Sweden, Switzerland, the United States and Yugoslavia had shown a marginal difference in favour of girls in numerical ability at the 13 year old age level (Foshay, 1962). Consequently, when the data from the First International Mathematics Study was analyzed, it was with some surprise that the null hypothesis on sex-related differences in mathematics achievement scores at each of the four population levels (9 years, 13 years, 17 years and Pre-University) was rejected (Husen, 1967). In every country studied males had outperformed females.

Since then, a large number of studies on sex-related

differences in mathematics achievement scores have been implemented in many of these countries, most of all in the United States. By the early seventies, interest in this issue in the United States had been "spurred by political groups who were fighting the occupational segregation existing in their country and who had identified mathematics as the critical filter preventing access to many jobs and careers" (Mura, 1982, p.16). As a result, a series of intervention measures to promote female achievement in mathematics gained impetus (Blum & Givant, 1982; Fennema, Wolleat, Pedro, Becker, & DeVancy, 1981; Fox, 1976b; Sells, 1982) and a narrowing of sex-related differences has been observed (Armstrong, 1981; Levine & Ornstein, 1983; Tobias, 1982). All the same, differences still exist in favour of males above the junior high school level (Kapoor, 1983; NAEP, 1980).

In the United Kingdom and Australia, there is some evidence of sex-related differences in mathematics achievement scores in favour of girls in the lower age group of 11 years and under (Byrne, 1978; Shelley, 1982); but male superiority seems to be the rule in older age groups (Cornelius & Cockburn, 1978; Harding, 1977; Kelly, 1976, 1981; Murphy, 1978; Preece, 1979).

That the situation is much the same in the countries of Western Europe is evident from a statement of concern on "education and equality of opportunity for girls and women" (Council of Europe, 1982, p. 1) expressed at the 11th session of the Standing Conference of European Ministers of Education at

The Hague in 1979. Consequently, a workshop was held early in May, 1981 at Honefoss where thirteen of the countries were represented. At the workshop, each of the countries -- Austria, Belgium, Finland, the Federal Republic of Germany, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom -- cited male advantage in career and occupation as a result of male superiority in mathematics and the physical sciences (Council of Europe, 1982).

Sex-related differences in mathematics achievement scores was a major topic at the Fourth International Congress on Mathematical Education held at Berkeley in 1980. As a result of the proceedings, an international survey was undertaken by Dr. Erika Schildkamp-Kundiger, in cooperation with the Second International Mathematics Study (IEA), and published under the title "An International Review of Gender and Mathematics" in 1982. The contributions from almost every country cited male superiority in achievement scores in mathematics and the physical sciences (Schildkamp-Kundiger, 1982).

Theories To Explain Sex-related Differences

It would appear that evidence of sex-related differences in favour of males in mathematics achievement scores in the developed world is unequivocal at the present time. But what is controversial is whether these differences are to be interpreted as evidence of innate superior mathematical ability in the male,

or as evidence of the extent of inequality of opportunity in relation to mathematical achievement that is built into human society.

The Nature-Position

Those who would favour the former interpretation, or what has been called the "nature-position", support it on grounds of biological or genetic differences between the male and the female (Benbow & Stanley, 1980, 1981, 1982; Broverman, I. K., Vogel, Broverman, D. M., Clarkson and Rosenkrantz, 1972; Buffery & Gray, 1972; Corah, 1965; Garron, 1970; Stafford, 1961, 1963, 1972). While such a theory dates far back into history, the rationale for it has changed periodically. At one point superior male intelligence was attributed to superior brain size, then to superior brain weight, or even superior muscle strength (Ellis, 1908; Lourbet, 1896; Mozans, 1913). The most persuasive theory at the present time seems to be developed along the following lines:

(1) Males have superior spatial visualization ability.

(2) Mathematical ability is positively correlated with spatial visualization.

(3) Therefore males are superior in mathematical ability.

That males have superior spatial ability is explained on the basis of (a) differences in lateral brain development, (b)

the X-linked chromosome inheritance theory, or (c) the theory of differential hormonal infuences.

The Nurture-Position

Those who support the alternate interpretation for lesser achievement scores in females, or subscribe to what has been called the "nurture-position" attribute it to socio-psychological-cultural factors such as:

(1) Sex-role stereotyping.

(2) Mathematics viewed as belonging to the male domain.

(3) Fear of ostracism by male peer group.

(4) Mathematics anxiety.

(5) Lack of mathematical activity in childhood.

(6) Lack of encouragement from parents and/or teachers and counsellors.

(7) Differential course-taking.

While neither position can be "proved" in the strict sense of the word, a basic tenet of generalizability in experimental research differentiates between the credibility of the two hypotheses generated. The nurture theory, which is based on factors extraneous to the individual, generalizes over a population to which those factors apply. That such factors apply to most of human society as it exists today is incidental. The nature theory on the other hand, generalizes over the human

race. Quantitative data that have generated this genetic theory have been gathered almost entirely from the developed world (Lancy, 1983). Empirical studies have been centred largely in the North American continent, Europe, Australia, New Zealand and Japan. The Soviet Union has consistently avoided considering sex as a determining factor in research studies in mathematics education (Krutetskii, 1976; Menchinskaya, 1946, 1969).

Hence, it would appear that a hypothesis for the human race is generated on the basis of evidence from a stratum of less than 25% of the world population. If any theory that speaks for humanity as a whole is to be considered, such evidence as is cited, should be manifest at all levels and strata (Lancy, 1983). The Second International Mathematics Study of the IEA currently in progress may provide such a probability sample. But empirical studies in diverse geographical, cultural and economic strata would seem to be necessary before theories of differential biological embedding of mathematical ability or abilities are entertained.

The Project

This study therefore, investigated whether sex-related differences in mathematics achievement scores exist in a sample from a different part of the world, in a different economic stratum, in a different culture and with a different educational history, viz. the State of Kerala in India. Limitations of time

and funds[1] restricted the study to two grade levels in three districts in the State.

Major Questions Posed in the Study

The two major questions posed in the study were:

(1) Are there sex-related differences in mathematics achievement scores at Grade 4 and Grade 8 levels in the urban schools tested?

(2) Are there sex-related differences in mathematics achievement scores at Grade 4 and Grade 8 levels in the rural schools tested?

A secondary objective was to determine if the findings in (1) and (2) had any bearing on the "nature" and "nurture" positions on sex-related differences in mathematics achievement scores.

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Reasons for the Separate Study of Urban and Rural Samples

The reasons for the separate study of urban and rural samples are best illustrated by the study of another investigation in India which did not draw any such urban-rural distinctions. In the second phase of the First International Study conducted by the IEA, a "Six Subject Survey", science among them, was conducted across 22 nations. Three of these countries, Chile, India and Thailand were from the under-developed world. But the mean scores for these countries were so low in all subjects that they were excluded from most of the more detailed analyses (Comber & Keeves, 1973).

In a later analysis of the data from India where the metropolitan and rural schools were separated, it was found that the mean for the city schools at the population II, III and IV levels (14 year olds, 17 year olds and Pre-University) exceeded the median for the developed countries while that for the population I level remained below (Shukla, 1974). The analyses showed that differences were small between Indian and international scores in urban areas, the difference decreasing with higher levels of population; but that differences were large in rural areas, the difference increasing with higher levels of population. A sharp drop in mathematics achievement scores with higher grade levels from the primary stage has also been reported from another recent study in an under-developed area, viz. The Indigenous Mathematics Project in Papua, New

Guinea (Lancy, 1983).

In India, any study of academic achievement is confounded by the large illiteracy figures that combine with caste, class and economic status to make within-country differences between rural and urban areas almost as large as the differences between India and the developed world (Jayaraman, 1981; Shukla, 1974). That these conditions confuse findings from any investigation of a conventionally representative sample of a reasonable size is evident from some other facts surrounding the Six Subject Survey in India. At the time of the study, 80.1% of India's population lived in villages (the figure for 1981 was nearly the same, 80%), 70.65% of the population was illiterate and an estimated 30% or more lived below the poverty line (Iyer, 1970). In the Six Subject Survey, India took part in science and reading, and samples were drawn from the Hindi-speaking States as the largest one-language region in the country. There are 14 other official languages in India and 1652 mother-tongues of which only about 400 are non-literate (Pattanayak, 1981). Even if only those languages that are spoken by 50 000 people or over are counted, there are still 25 different languages in the country, with educational standards varying widely among the various language groups (Jayaraman, 1981).

On the variable of literacy, the relevant figures were: Bihar - 19.97%, Madhya Pradesh - 22.03%, Haryana - 26.69%, Rajasthan - 18.79%, Uttar Pradesh - 21.64% and Delhi - 56.65%.

Delhi alone, a metropolis with a population of 4 million, raised the literacy figure of the sample to that for all of India, 29.35. The rest of the states represented a total population of 222 million (Shukla, 1974). A representative sample of schools in these states could not, and did not, include any of the schools teaching in the medium of English (which are attended largely by middle and upper class children in urban areas) as less than 4% of the Indian population is acquainted with the English language even today (Pattanayak, 1981). Yet, the effective administration of the country in every aspect draws largely from this section of the population (Lewandowski, 1980). As has been mentioned, the result of the International Study was that the scores, both in science and in reading, were so low that no worthwhile analyses could be made.

That any small sample randomly selected, even if proportionately stratified, cannot present an accurate picture of the country may be evident from a few other statistics: (1) that 450 million illiterate people, an estimated 50% of the world's illiterate population, live in India (Manorama Yearbook, 1983). (2) that the third largest pool of scientists and technical personnel in the world live in India (Prasad, 1983). (3) that India is the 9th most industrialized country in the world (Narayanan, 1982). (4) that India provides technological know-how to 37 other nations, including some in the developed world (Ummat, 1982).

This study therefore, takes into cognizance the fact that the middle classes of India, living in its urban areas, whose total numbers exceed the combined populations of the United Kingdom, Canada, Japan and France, but who are yet outnumbered 5 to 1 by the less privileged, living mostly in the rural areas (Census Commissioner of India, 1981) merit study in their own right. As this investigation is a limited individual project on a sample of about 1400 subjects, no probability sampling was attempted. Instead, the study was confined to three districts in a single state, Kerala, and samples were drawn from its rural and urban areas and studied separately.

Reasons for the choice of Kerala

The choice of Kerala was partly one of convenience (it is the investigator's home state), and partly due to the fact that the state is distinctive in India in the area of public education. Ever since census studies were initiated in 1881, Kerala has consistently registered the highest literacy figures in India (Lewandowski, 1980). At present the literacy figure for Kerala is 69.17% and that for all of India, 36.17% (Census Commissioner of India, 1981). The female literacy figure for Kerala is 64.48%, the highest in India. The state of Maharashtra follows next in rank with a female literacy figure of 35.08%.

In the past six years the state has almost achieved what

remains a target for the rest of the country, 100% enrollment of its 6-11 year olds in school (Government of Kerala, 1981). But this rapid advance in public education on an economy that is the poorest among all the states, has not been without its anomalies. One quarter of Kerala's schools lack washrooms, one third lack drinking water, one half have no electricity (Government of Kerala, 1978). These facts must speak for what educational facilities in the nature of books, laboratories, gymnasiums, arts and crafts etc. the schools are likely to have. The state spends 55% of its revenue on education. Yet the expenditure per pupil per school day works out to 17 cents in elementary schools and 25 cents in the high schools (Government of Kerala, 1979). The average expenditure for elementary through secondary school in British Columbia for the year 1980-81 works out to $21 per pupil per school day despite the fact that the province spends no more than 15.5% of its budget on education (Statistics Canada, 1983).

In many ways Kerala epitomizes the contradictions that prevail in India. It is the smallest state (area: 38 863 km^2), with the highest density of population, 654 persons to the square kilometer (the average in other states is 387). The state also has the lowest death rate in India, and the lowest figures for infant mortality, which is attributed to its higher level of female literacy (Chattopadhyay, 1983). With Education, Family Planning and Health Care together accounting for three quarters

of its expenditure, the State has also succeeded in bringing down the population growth rate to 1.80 per thousand per annum, the lowest growth rate in India (Narayanan, 1982).

The female-male ratio in India had progressively declined to 935 females per 1000 males over the past century, which has been associated with differential treatment meted out to girls in food and nutrition within the family. For Kerala alone, the ratio is about the same as for the rest of the world, 1035 females to 1000 males (Manorama Yearbook, 1983).

But for every departure from the norm can also be cited a point of conformity with the rest of India. For instance, while female teachers outnumber male teachers by 9% in Kerala, the highest levels in schools, be it primary, upper primary or secondary, are taught more by males than females (Government of Kerala, 1981, see Table 15). The sex-related hierarchy is unmistakable.

Chapter 2

REVIEW OF RELATED LITERATURE

In a review of literature on sex-related differences in mathematics achievement in the United States, Elizabeth Fennema (1977) draws a dividing line around 1974. Studies reported before that date show differences in favour of males while those reported after that date are more ambivalent. The reasons behind this shift in trends can be seen in two major factors. First of all, there has been a reduction in sex-related differences in mathematics achievement scores (Blum & Givant, 1982; Dees, 1982; Levine & Ornstein, 1983; Schonberger, 1976; Sells, 1982; Tobias, 1982; Usiskin, 1982).

Secondly, the less disparate achievement scores between the sexes in combination with the more sensitive climate of controversy as a result of the active feminist and equal rights movements in the country (Mura, 1982), is leading to more cautious conclusions being drawn from the data (Gray & Schafer, 1981). All the same, it must be mentioned that there are some notable exceptions to this trend (Benbow & Stanley, 1980, 1981, 1982).

Canada and the United States are not always differentiated in educational research as there are, undeniably, a great deal in common between the two countries. Yet, the differences that

exist in educational and social environments could be considerable in certain areas (Mura, 1982). It is evident in that neither of the factors described above apply wholly to Canada. Sex-related differences in mathematics achievement scores were first mentioned in Canada with the British Columbia Learning Assessment Studies of 1977 (Mura, 1982). Such research as has been reported since then cite larger and not smaller sex-related differences (Robitaille, 1981; Sawada, Olson and Sigurdson, 1981).

British Columbia Learning Assessment Studies

In the first Learning Assessment Study in British Columbia (1977), the test content was divided into three domains: Computation and Knowledge, Comprehension, and Applications. In the nine comparisons possible in these domains at the grades 4, 8 and 12 levels, girls outperformed boys in the computation domain in grades 8 and 12. In the seven other comparisons the boys were superior although all differences were small. Nevertheless, the differences must be considered educationally significant as the study was based on a census and not a sample.

The study also drew attention to the fact that girls did not elect to take mathematics subjects in the same proportion as boys. While the male-female ratio was 51 to 49 at the Grade 4 and Grade 8 levels, in the optional Algebra 12 group it was 58 to 42 (Robitaille & Sherrill, 1977).

In the second Learning Assessment Study (1981) conducted four years later, the test was divided into five content domains: Number and Operation, Geometry, Measurement, Algebraic Topics and Computer Literacy. In mean scores, at the Grade 4 level, there were significant differences only in two domains: in Geometry in favour of girls and in Measurement in favour of boys, both differences being small. At the Grade 8 level, there were significant but small differences in three areas: Geometry, Measurement and Computer Literacy; all three were in favour of boys. At the Grade 12 level there were significant differences in all domains ranging between 7% and 17%, all in favour of males.

In the Learning Assessment Study of 1981, a further analysis was done by dividing the Grade 12 population into sub-populations of those whose last or current mathematics course was Algebra 12, Algebra 11 or Mathematics 10. It was found that males outperformed females in each of the sub-populations, in each of the domains. It was only on a single objective within the domain of Algebraic Topics that there was no sex-related difference.

The male-female ratio in Algebra 12 had increased to 60 to 40 in the interval. The ratio was similarly high in Computing Science, Geometry and Trade Mathematics (Robitaille, 1981).

As demonstrated by scores in the two Learning Assessment Studies of 1977 and 1981, where domains were classified

differently but overlapped considerably in content, sex-related differences in favour of males in mathematics achievement had widened in British Columbia. Females also continued to be a minority in upper level optional courses in secondary school mathematics.

Alberta Assessment Of School Mathematics

In the spring of 1978, the province of Alberta conducted an assessment study in mathematics at the grades 3, 6, 9 and 12 levels (Olson, Sawada and Sigurdson, 1979; Sawada et al, 1981). The content areas were: Number, Algebra, Geometry, Measurement and Statistics over the three cognitive levels of Knowledge, Comprehension and Application. An analysis was made of the number of instances where the mean score for one sex was significantly superior to the mean score for the other sex. On this criterion, comparison by grade-level indicated that males outperformed females 17 to 11 at Grade 3, 26 to 10 at Grade 6, 28 to 6 at Grade 9 and 43 to 3 at Grade 12. By mathematical content area, in the 20 comparisons possible, only in the area of Number at the Grade 3 level did females do better. All other comparisons favoured boys. By the three cognitive levels, males did better than females 15 to 9 in Knowledge, 30 to 6 in Comprehension and 33 to 2 at Applications. At the Knowledge level alone girls were ahead at grades 3 and 6, but the boys were ahead by Grade 9, and considerably so by Grade 12.

The Alberta study seems remarkable not only for its consistent findings of male superiority in mathematics achievement scores by grade, by content, and by cognitive levels, but also for its extreme caution in drawing conclusions from such unequivocal data. The authors recommend examining school systems, modes of instruction and choice of test items for sex bias. They suggest that as 90% of the test items were selected from studies in the United States such as the National Assessment for Educational Progress (NAEP) which have been found to be sex biased (Tittle, McCarthy and Steckler, 1974), it is possible that such a bias pervades this study as well. The report concludes with a recommendation that Canada investigate what sort of socio-educational-cultural variables give rise to male superiority in mathematics so that changes may be introduced to give females a fair opportunity in an area of such significance.

Case for Sex-related Differences in Mathematical Reasoning Ability

In direct contrast to the inferences drawn from the Alberta Assessment of School Mathematics (Olson et al., 1979; Sawada et al., 1981) is that done in the Study of Mathematically Precocious Youth (SMPY) at Johns Hopkins (Benbow & Stanley, 1982). Between 1972 and 1974 the SMPY identified, through a

talent search, over 2000 seventh and eighth grade students who had performed as well as the national sample of eleventh and twelfth grade females at the Mathematics (SAT-M) and Verbal (SAT-V) sections of the Scholastic Aptitude Test. Benbow and Stanley pursued the mathematical careers of these students through the following five years. It was found that in relation to successive SAT-M and SAT-V scores, scores on the Advance Placement Program Examination in Calculus, and on the Mathematics Achievement Test, Levels I & II, males scored higher than females.

Therefore, it was hypothesized, that males may have superior mathematical ability for genetic reasons of either differing lateral development of the brain, or prenatal hormonal influences (Benbow & Stanley, 1982). However, the data revealed:

(1) that males took more mathematics courses than females especially in College Algebra, Analytic Geometry and Calculus, although all subjects took the same mathematics courses up to Grade 11 level (p.604);

(2) that males took the courses one semester earlier on an average, than did the females (p. 604);

(3) that the proportion of females taking the upper level optional courses in mathematics was smaller than for boys (p. 608).

When females did take these courses, it was reported that their

mean course grades were marginally higher than those for males. This fact was explained by the observation:

> The mathematics course-grade differences can probably be explained by the sex differences favouring girls that have been found in conduct and demeanor in school (Baker, 1981; see Entwisle & Hayduk, 1981, in press). Girls have better conduct and demeanor. This possibility is consistent with the stronger relationship between mathematics reasoning ability and mathematics course grades for boys than girls. Unfortunately, we could not control for conduct or demeanor. (p.617, emphasis added)

What can be inferred from the reported data is that females did not take mathematics courses semester after semester as did the males but only with breaks (and losses?). The "mathematics reasoning ability" referred to is the measure of the SAT-M score at the time of the talent search, and the "stronger relationship..." translates to the fact that boys' scores were high or low in the courses depending on whether they were high or low in the SAT-M, but girls' scores in the courses did not follow the pattern of their scores in the SAT-M. The inference could well be that one needs to explain away the higher scoring of girls in mathematics courses, as the authors have done; or that the performance of girls in the SAT-M tended to be erratic. When one considers that scores on the SAT-M were supposed to predict aptitude for mathematics, and that course grades are supposed to indicate achievement in mathematics, it appears to be inconsistent that mathematics reasoning ability should be identified with the prediction criterion, but should be

summarily divorced from mathematics achievement to make way for "conduct and demeanor".

Another questionable aspect of the Benbow & Stanley (1982) study is the persistent use of "mathematical reasoning ability" interchangably with SAT-M scores. Apart from the instance cited earlier, to cite a few others:

(1) "when mathemaical reasoning ability was controlled for..." (p. 611), when what was meant was that SAT-M scores were controlled for.

(2) "the less well developed reasoning ability of girls..." (p. 618), when what the authors had access to were the lower SAT-M scores of girls.

(3) The conclusion:

> "We conclude that sex differences in mathematical reasoning ability and achievement are widely noted in this highly able group of students, they persist over several years, and they are better accounted for by the sex difference in mathematical reasoning ability than by sex differences in expressed attitudes toward mathematics and mathematics course taking in junior and senior high school" (p. 619).

There appears to be no evidence in the research literature to indicate that the quest to identify mathematical reasoning ability which began with Hadamard (1954) and Poincare (1963) concluded with the SAT-M. On the contrary, it appears that the quest goes on (Luchins & Luchins, 1980). In fact, the ability of the SAT-M even to assess mathematical reasoning ability has not

gone unquestioned (Aiken, 1982; Gray & Schafer, 1981). In a study commissioned by the College Entrance Examination Board, it was found that while SAT-V was impervious to coaching and drilling, SAT-M scores could be raised by as much as one standard deviation by such preparation (Pike & Evans, 1972).

As a further conclusion, Benbow and Stanley extend the identification of SAT-M scores from mathematical reasoning ability to general reasoning ability. To quote the authors:

> "Moreover, why boys tend to reason better than girls from at least as early as second grade (Dougherty et al., Note 5) onward is also, of course, not clear" (p. 620).

On the basis of the data presented in the last two studies (Benbow & Stanley, 1982; Sawada et al, 1981), it would appear that it is Sawada et al., rather than Benbow & Stanley, who have uncontroversial evidence of male superiority in mathematics achievement scores. While it is Benbow and Stanley, and not Sawada et al., who claim genetic male superiority in mathematical reasoning ability.

These two studies have been dealt with at some length as they demonstrate dramatically that: (1) superior male performance on mathematics achievement tests is still a fact, and (2) that interpretations of related factors and circumstances are highly subjective, and may be used to lend support to any plausible theory for sex-related differences.

Historical Perspective

No assessment of theories of inherent or genetic or gender-based male intellectual superiority can be placed in perspective unless it is considered in its historical context. Aristotle is an oft-quoted authority on the theory, and no doubt he had innumerable unrecorded forbears. The preoccupation of trying to "prove" such theories logically seem to have originated with the spurt in mathematical thought in the Renaissance period in Europe. With Newton and Leibnitz began not only the calculus, but an "if-then" approach to sociological problems (Davis & Hersh, 1981).

This search to give logical backing to blindly-accepted theories can be seen in the measuring and weighing of craniums and grey matter to provide scientific proof for the effective superiority of male over female, white over black, west over east (Gould, 1981; LeBon, 1879; Vogt, 1864). But even if such proof has proved elusive (Chorover, 1979), the means have become progressively more sophisticated. The current theory is one of superior male spatial ability due to differential brain lateralization (Bufferey & Grey, 1972; Harshman & Remington, 1976; Levy, 1972, 1974; McGee, 1979; McGlone & Kertesz, 1973).

Granting that biological differences in the human anatomy and related functions must exist between the male and the female, it is of interest to investigate the succeeding two

steps in the logical sequence:

(1) that males are superior in spatial visualization,

(2) that mathematics achievement is dependent on spatial visualization.

Are Males Superior in Spatial Visualization Ability?

Up to the mid-seventies, superior spatial visualization ability was almost uniformally associated with males (Carey, 1915; Fennema, 1974; Maccoby & Jacklin, 1974; Schonberger, 1976). Since then inferences from data have become less conclusive.

In the Fall of 1978, the Education Commission of the States (ECS) conducted the Women in Mathematics Project, a survey of 13 year olds and high school seniors in the United States. At about the same time the ECS also conducted the second National Assessment of Educational Progress (NAEP). In the Women in Mathematics Project the test content was divided into the four domains of Computation, Algebra, Problem Solving and Spatial Visualization and in the NAEP it was divided into the three domains of Computation, Algebra and Applications. In Computation and Algebra, neither study showed any significant difference between males and females at the 13 year level. There was no significant difference in the problem-solving domain, but there was a significant difference in favour of males in Applications

and a similar significant difference in favour of females in spatial visualization (Armstrong, 1981; NAEP, 1980).

It can be concluded that evidence of superior spatial visualization ability is ambivalent between the sexes.

Is Mathematics Achievement Dependent On Spatial Visualization Ability?

In a study sponsored by the National Science Foundation in the United States, a probability sample of 1330 students in grades 6-8 in four school areas were studied (Fennema & Sherman, 1977). There were significant sex-related differences in achievement in favour of males in one of the areas but it was not accompanied by any difference in spatial visualization. In the same study in grades 9-12 (N=1233), two of four schools showed significant differences in favour of males in mathematics achievement but only one of them showed a male advantage in spatial visualization.

A causal relationship between spatial visualization and mathematics achievement has been questioned by Werdelin despite what apparantly is a "strong pedagogical reason to believe in a connection between the ability to visualize and geometric ability" (Werdelin, 1971). Logical as such a connection appears to be, empirical research has failed to establish its existence (Aiken 1973; Fruchter, 1954; Lean & Clements, 1981; Murray, 1949; Radatz, 1979; Smith, 1964; Very, 1967; Werdelin, 1971).

On the cognitive level, Twyman (1972) distinguishes between "memory images" and "abstract images" and the "use" of imagery. The irrelevant details in visual images, he said, could distract the "original stimulus" from making the necessary abstractions. A similar distinction in cognitive abilities is made by Menchinskaya (1946) and Krutetskii (1976). Krutetskii categorizes problem solvers into three types: analytic, geometric and harmonic, where those in the last category shift between the other two modes with ease. However, the geometric mode was found to be more restrictive than the analytic mode. Lean and Clements (1981) in reviewing literature related to spatial visualization and mathematics achievement make the statement that mathematics educators may need further research done to clarify the implications of information-processing theories. They quote the experience of educational psychologists who had conducted research for decades on the assumption that "auditory" and "visual" learners could be identified, only to find that evidence of their separate existence was ambiguous (DeBoth & Dominowski, 1978; Jensen, 1971).

Lean and Clements (1981) in their study of 116 foundation year engineering students at Papua, New Guinea, administered a battery of five spatial ability tests, a test in Pure Mathematics and a test in Applied Mathematics. Multiple Regression analysis of data revealed that all of the spatial ability tests together accounted for 10% of the variance in Pure

Mathematics, and after the effects of Pure Mathematics had been partialled out, it accounted for 2% of the variance in Applied Mathematics. One inference drawn from the analysis was that "the tendency towards superior performance on mathematics tests by students who preferred a verbal-logical mode of processing mathematical information might be due to a developed ability to abstract readily, and therefore avoid the formation of unnecessary images" (Lean & Clements, 1981, p. 296). This was further supported by a study on seventh grade students in Victoria, Australia, by Suwarsono (Clements, 1981, 1982).

The greater significance of analytical skills over spatial skills was the finding in another study done in New Delhi, India in 1963-67 (Sharma, 1973a, 1973b). Students from standards 8-11, where standard 11 was the final year of secondary school, in the 12+ to 19+ age group (N=2628), were the subjects in a combined cross-sectional and longitudinal study on achievement scores in the six areas: verbal, numerical, mechanical and spatial abilities, deductive reasoning, and clerical speed and accuracy. The students were divided into five ability levels on the basis of their mean comprehension scores on the tests and growth curves were traced for each domain by class, by modal age in each class and by ability levels in each class.

The growth curves showed that: (1) verbal and reasoning abilities were very high for the upper levels in standard 8, but that those at lower levels grew at a faster rate so that the gap

was narrowed by standard 11; (2) Numerical ability, mechanical ability, clerical speed and accuracy grew at parallel rates so that whatever differences there had been between the various levels at standard 8 was maintained through to standard 11; (3) In spatial ability alone, the abler groups not only started at a higher level in standard 8, but progressed at a faster rate so that the gap widened considerably by standard 11.

These results more or less conform with the Benbow and Stanley (1982) finding that males who were lower than females on the SAT-V scores in the Talent Search almost wiped out the difference by the end of high school, while growth in SAT-M scores were only slightly higher for males. But conformity ends with the data. Benbow and Stanley concluded that males grew at a faster rate than females. Sharma inferred that there was a plateauing in verbal and reasoning abilities so that those who reached high levels earlier grew at a slower pace. No sex-related differences were studied although the sample was a mixed one.

Another interesting result from the Sharma study was that when the six abilities were rank ordered for each of the five levels in each class, for the top level, spatial ability ranked the last in standard 8, 4th in standard 9, and 5th in standard 10 and standard 11. Verbal, Numerical and Reasoning abilities outranked spatial ability in each of the classes with a single exception of verbal ability following spatial ability in

standard 9. The question arises as to how much of the variance in achievement scores for the high scorers would have been accounted for by spatial ability after the effects of verbal, numerical and reasoning abilities had been partialled out. Even on the basis of rank ordering, the results seem to be in conformity with that of Lean and Clements (1981).

In an earlier study of the SMPY (Benbow & Stanley, 1980) it was reported that between 1972 and 1979, high scoring males far outnumbered high scoring females in SAT-M. The authors therefore "favoured the hypothesis that sex differences in achievement in and attitude toward mathematics result from superior male ability, which may in turn be related to greater male ability in spatial tasks." (Benbow & Stanley, 1980, p.1264) But as yet, while there has been fair evidence that high levels of spatial ability are found among high achievers in mathematics, and low achievers in mathematics are low in spatial ability, there has been no evidence that it is the superior spatial ability that contributes to the superior mathematics achievement. In fact there is evidence that mathematics achievement can be high with or without superior spatial visualization ability (Fennema & Sherman, 1977; Lean & Clements, 1981; Roach, 1979; Robinson & Gray, 1974; Satterly, 1968, 1976)

Present Status Of Genetic-based Theories

If the genetic-based theories for sex-related differences

in mathematics achievement scores are based on superior male spatial visualization ability, it would appear that recent findings disrupt the sequence of logical deduction described on page 4, though they do not discredit the theories per se. Differential brain lateralization, or any of the other factors, could bring to light some other discriminating ability which could account for the differential in achievement scores. Considering the relatively short span in which theories have shifted from brain size to brain side, such a discovery could not be considered unlikely. If Benbow and Stanley (1980, 1981, 1982) are representative of the school of thought that supports genetic, sex-related differences in mathematical ability, it is a point of note that it was data from the same study that generated a hypothesis of male superiority based on spatial ability in 1980, and one based on brain lateralization in 1982. In the interval spatial ability had become increasingly controversial as a discriminating factor, and the more comprehensive criterion of brain lateralization was needed.

Literature on the Nurture-Position

While neither nature, nor nurture, can be contrived, accident victims and war veterans who had sustained brain injuries provided some data for experimental studies on brain lateralization (McGlone & Kertesz, 1973). Even though no such opportunity exists for the study of induced changes in nurture,

experimental studies in the theory have been designed to demonstrate the sensitivity of female mathematics achievement scores to: sex-role stereotyping (Casserly, 1982; Fox, 1976a; Kagan, 1964; Kelly, 1981; Smithers & Collings, 1981), perception of mathematics as a male domain (Ernest, 1976; Fennema, 1977; Fox, 1977), anxiety and lack of confidence (Crandall, Katkovsky and Preston, 1962; Crosswhite, 1975; Ernest, 1978; Kagan, 1964; Maccoby & Jacklin, 1973; Seppie & Keeling, 1978; Tobias, 1976), lack of childhood mathematical activities (Fox, 1976b; Luchins & Luchins, 1980; Osen, 1974), fear of success (Fink, 1969; Horner, 1968; Humphreys, 1982), lack of encouragement from parents and/or teachers and counsellors (Osen, 1974; Tobias, 1982), and various combinations of these and other exogenous factors (Carey, 1958; McMahon, 1971; Ormerod, 1971, 1973, 1975; Schonberger, 1978; Sells, 1982; Spender, 1982).

The single most significant research evidence in support of the exogenous theory is the considerable range of overlap between male and female achievement scores in mathematics and the physical sciences (Fennema, 1977; Kelly, 1981; Tobias, 1982). This was evident in the First International Mathematics Study (Husen, 1967), in the SMPY (Benbow & Stanley, 1980, 1982) in the first, second and third NAEP studies (Kapoor, 1983; Mullis, 1975; NAEP, 1975, 1980), in the first and second British Columbia Learning Assessment Studies (Robitaille & Sherrill, 1977; Robitaille, 1981) and in the Women in Mathematics Project

(Armstrong, 1981). In each of these investigations, a large proportion of females scored as high as, or higher than a large proportion of males. In fact, Sharma and Meighan (1980) cite this observation as reason for their investigation of the GCE 'O' level mathematics scores in England for a more consistent reason for sex-related differences. The Sharma & Meighan study resulted in finding a significant correlation between mathematics achievement scores and whether or not the subject was a student of physics as well, rather than the sex of the subject.

In the First International Mathematics Study, cross-national differences far exceeded the sex-related within-national differences. For instance, sex differences at the 13-year-old level were greatest in The Netherlands, Belgium, Japan and England. But the "low-achieving" girls of these countries outperformed the "high-achieving" boys of many other countries including the United States. Another result of the study was that Israel had the highest mean score for the 13 year old population and Israeli girls scored higher than Israeli boys both in verbal as well as computational subtests (Husen, 1967).

But overall, in the 42 sex-related comparisons that were made, boys had the advantage in 40 of them. Benjamin Bloom, summarizing the results on sex-related differences concluded with this statement:

> We had originally attempted to understand these differences in mathematics as functions of the

> differential roles of males and females in the different countries. However, we find so few exceptions to the rule of male superiority in mathematics that we are led to believe that variation in the roles of the sexes in these countries will not be helpful in understanding mathematics achievement differences between the sexes (Husen, 1967, p.259, emphasis added).

In the two decades that have elapsed since that study, although there are indications that sex-related differences in some of the countries have narrowed (Brush, 1980; Levine & Ornstein, 1983), and studies in differing sex-roles partially accounted for the differences to the conviction of some, essential sex-related differences and the attendant controversy over its implications still persist in these countries. Studies in other countries for an added dimension on the issues appear to be necessary.

Summary

Research evidence therefore appears to indicate that:

1. Sex-related differences in mathematics achievement scores exist in the developed world (Husen, 1967; Kapoor, 1983; Kelly, 1981; NAEP, 1975, 1980; Robitaille, 1981).
2. The difference in scores in favour of males, widens with age and grade level (Kapoor, 1983; NAEP, 1975, 1980; Robitaille & Sherrill, 1977; Robitaille, 1981; Sawada et al, 1981).
3. In the past decade these differences have tended to

decrease in the United States, but they still exist (Benbow & Stanley, 1980; Blum & Givant, 1982; Levine & Ornstein, 1983; Sells, 1982; Tobias, 1982).

The rationale for male superiority in mathematics achievement scores still evident regardless of observed trends is mainly divided into two schools:

I. The Nature-Theory, which is based primarily on the sequence of deductions that (i) mathematics achievement scores are dependent on spatial visualization ability, and (ii) males are superior in spatial visualization ability (Carey, 1915; Fennema, 1974; Maccoby & Jacklin, 1974).

Recent studies, however, make the assumption of male superiority in spatial visualization ability questionable (Armstrong, 1981; Fennema & Sherman, 1977). Even if such superior spatial ability should exist, whether achievement in mathematics is dependent on spatial ability has become increasingly dubious (Aiken, 1973; Clements, 1982; Fruchter, 1954; Lean & Clements, 1981; Murray, 1949; Radatz, 1979; Smith, 1964; Very, 1967; Werdelin, 1971). That spatial visualization ability contributes little to superior mathematics achievement was the conclusion in many such studies (Krutetskii, 1976; Lean & Clements, 1981; Menchinskaya, 1946; Roach, 1979; Robinson & Gray, 1974; Satterly, 1976; Sharma, 1973a, 1973b).

II. The Nurture-Theory, attributes sex-related differences in

mathematics achievement scores to sociological, psychological and environmental factors. While considerable research has been done in this area of investigation, evidence that sex-related differences in mathematics achievement scores exist solely because of such factors has yet to be demonstrated.

However, mathematics achievement scores of females have been shown to be sensitive to socio-psychological and environmental factors (Crosswhite, 1975; Ernest, 1976; Fennema, 1977; Fox, 1977; Humphreys, 1982; Luchins & Luchins, 1980; Newton, 1981).

Some Studies In Other Cultures

Recent studies in the West Indies and on West Indian and Asian children in Britain have produced results at variance with many that have been cited. Roach (1979) tested 206 boys and 212 girls randomly chosen from Grade 6 classes in 5 Jamaican schools on mathematics achievement, conceptual style and intelligence. It was found that mathematics achievement had significant positive correlations with analytical conceptual style and intelligence and that the mean scores for girls were significantly higher than that for boys ($p<.01$). The variance among girls was also found to be larger than that for boys. Most studies up to now have recorded not only higher scores for males, but also a higher variance among males. No significant

sex-related differences had been found in Jamican schools in two earlier studies as well (Vernon, 1961; Isaacs, 1974).

Driver (1980) studied achievement in mathematics, science and English of 2300 West Indian, Asian and English sudents of the 16+ age group from 5 multiracial schools in Britain. In mathematics and science, Asian boys and girls (no differences are mentioned) did best of all, and the ranking among the others was, West Indian girls, English boys, West Indian boys and English girls, in that order. As larger numbers of English girls dropped out of higher level mathematics courses than others further analysis was done controlling for course background. The West Indian girls still kept their rank.

Jahoda (1979) compared 72 Ghanian children in grades 2, 4 and 6 (in their last three weeks of school) with a parallel group in Scotland in grades 3, 5 and 7 (in their first three weeks of school) in spatial perception tasks. A significant sex-related difference in block construction in favour of males was the same in the two samples. There was no difference in either group in mental rotation or pattern assembling.

Tanner and Trown (1979) investigated the effects of cultural change on mathematical thought by studying samples of immigrant Asian school children in two age groups, 10/11 years and 12/13 years, from 22 schools in 11 towns in the industrial northwest of England. Among children who had had all their primary education in the country, Asian girls were markedly

superior to their male counterparts at age 10/11, and marginally so at 12/13.

Some Recent Studies in India

Sex-related differences in mathematics achievement scores have not been an issue in educational research in India as the preoccupation in the country is still mainly with the problem of illiteracy (Sunder, 1982). However, a few studies that have a tangential bearing on this investigation are cited below.

Sinha (1980) compared the competence of students from four typical schools, a government boys' school, a government girls' school, a private boys' school and a private girls' school, with a total of 5200 students. Competence was operationally defined to cover components such as acquisition of skills, self confidence, positive self concept, internal control of reinforcement, moderate and/or high level of achievement and positive leadership qualities among others. The private girls' school ranked first on leadership qualities, intelligence, extroversion and self concept. That the result does not extend to all girls is indicated by other studies of status and personality of women across India (Gaur, 1980; Sharma, 1979), which found that while women of the upper classes held themselves responsible for their success, the middle and lower classes held God or Fate responsible. Upper class girls in India are to be found almost entirely in private girls' schools

(Jayaraman, 1981).

Chauhan and Singh (1982) in an investigation into the study habits of 500 10-12 year olds in the Simla district found no sex-related differences in either urban or rural populations, but the mean scores, according to the manual of the Study Habits Inventory used, were average in urban areas and below normal in rural areas. The effect of parental profession on study habits was also found to be significant at the .05 level. The order of mean scores by parental profession were: Teaching-171, Government Services-163, Defence Services-161, Business-160, and Agriculture-156.

Another study investigated the differences in the role of the secondary school teacher in urban and rural areas (Shah, 1971). The data revealed that: (1) heads of urban institutions were generally better qualified than heads of rural institutions; (2) heads of institutions, teachers and parents in urban areas set subject-training as the objective of top priority while in rural areas the priority was on character-building, good-citizenship and subject-training, in that order.

Bhargava (1982) studied the effects of prolonged deprivation on academic achievement. The independent variables covered 15 material, social and emotional dimensions such as food, clothing, housing, motivational experiences and childhood experiences. 13 of these dimensions were found to be significant, 8 of them at the .01 level. A crucial result was

that these factors affected the potential high achievers, male and female, far more than the low achievers. However, no study was made as to whether the effects varied in extent with sex.

Chapter 3

METHOD

In India, standardized achievement tests in mathematics have yet to be used in educational studies. In the mathematics papers of public examinations conducted at the end of the high school program throughout the country, girls have been found to do just as well, or better than boys (Hate, 1969). But a general comment on the superior performance of girls in external examinations in India has been that the questions are largely designed to test textual knowledge and therefore more likely to favour females than males (Hate, 1969). Hence, in this study it was considered that the results would be more definitive if test items that had already been used on known samples in the developed world were chosen rather than indigenous ones. The items were therefore selected from the British Columbia Learning Assessment Study of 1981 (Robitaille, 1981), and the Second International Mathematics Study conducted in British Columbia in 1982 (Robitaille, O'Shea, & Dirks, 1982).

Considering the large disparity in technological development, economic sufficiency, standard of living and educational objectives, a direct comparison of mean scores between Kerala and British Columbia would be neither justifiable (Shukla, 1974; Inkeles, 1979; Niles, 1981a, 1981b), nor

profitable. But it was hoped that an analysis of sex-related differences in a section of the population of India, on the basis of tests used in a developed region such as British Columbia, would extend the frontiers within which such investigations have been made. A description of the method and procedure employed in the study is presented in this chapter.

Sample

A total of 1377 students in 37 classes from 18 schools in 3 districts of Kerala were tested. The distribution was: 781 students from standard 9 (384 boys and 397 girls) and 596 students from standard 5 (300 boys and 296 girls).

The total population in these grades in the schools in the sample were: 3798 in standard 9 (1789 boys and 2009 girls) and 2107 in standard 5 (1124 boys and 983 girls), for a total of 5905 students.

The three districts in Kerala were selected on the basis of location and educational history: Cannanore at the northern end, Ernakulam in central Kerala and Trivandrum at the southern tip (see map in Appendix I). Historically, they represent the three different sections of British Malabar and the Princely States of Cochin and Travancore, each of which had a different educational system up to 1956. As an index of the differences in their educational history, the female literacy figures for 1891 for the three areas were, 0.66% for British Malabar, 3.76% for

Cochin State and 2.69% for Travancore State when the figure for all of India was 1% (Lewandowski, 1980). The three regions were merged in 1956, on the basis of their common language Malayalam, to form the state of Kerala. Since then, the education system has been uniform throughout the State.

School Structure in Kerala

At present, there are two different school structures in Kerala: (1) The Higher Secondary Schools run by the Central Goverment with a uniform system all over India. These schools are for the children of Government servants and members of other public services who are subject to transfer from place to place, so that their studies do not get interrupted. These schools, which are all located in urban areas, run through 11 standards; standard 10 and standard 11 covering the senior secondary stage of most American schools in the Arts and Sciences. Graduates from these schools are admitted directly to a degree program in the universities; (2) The Secondary School Leaving Certificate (SSLC) structure that is followed by the large majority of government and private schools in the State. The schools run through 10 standards; the first four standards constitute the primary section, the next three standards, 5-7, constitute the upper primary section, and the last three standards, 8-10, constitute the high school section. The last two years of high school allow for some selection of courses, but mathematics is a

compulsory subject. Graduates of this school system undergo two years of pre-university studies before they are admitted to a degree program.

Selection of Sample

As the majority of schools in Kerala follow the latter system -- over 500 000 candidates appeared for the SSLC examination of 1983 -- the samples were drawn entirely from this section of the school population. The total number of such schools in the three districts selected were 3565, and the total number of students at the two grade levels under study (standards 9 and 5), were 350 000 (Govt. Of Kerala, 1981). As mentioned in Chapter 1, with the limited size of sample envisaged in the study and the wide disparity in standards between the various schools in quality of instruction, class, caste, economic status and educational history of population, no sampling on a representative basis was attempted. Instead, a list of schools that represented the mode in educational standards was drawn up by the Evaluation Department of the State Insitute of Education, Kerala, located at Trivandrum. This list was drawn mainly on the basis of the percentage of passes from the various schools in the SSLC examination at the end of standard 10. The schools in the sample were then selected from this list.

In the rural areas, there was one coeducational high school

per village. There were no single-sex schools. The selection could therefore be made randomly from the comprehensive list of rural schools. The urban selection was made so that at least one Boys' school, one Girls' school and one coeducational school was selected from each district. The single-sex schools were selected on the basis of parity of standing. To cite an example from British Columbia, if St. Thomas More Collegiate (a Boys' school in Burnaby) was selected from the Boys' schools, it would be paired not with Crofton House School for Girls which is more "elite", but with Marian High School (a Girls' school in Burnaby run by the same religious order) which is fed by the same families as the Boys' school. Or, it might be said that the Boys' schools and Girls' schools were selected in matched pairs.

The classes at the various standard levels were chosen by the heads of schools in the sample. No system of streaming was followed in any of the schools. The classes were divided almost always by alphabetical order of names; except in the case of girls, which is discussed in the following paragraph. The same teacher, or at most two teachers, taught mathematics to all the classes in Standard 8. At the primary levels, mathematics was taught by the class teacher in almost all schools. In terms of numbers in a class, Standard 8 for girls in rural areas tended to be the more numerous; the largest number encountered was 62. In general, all-female classes tended to be larger than all-male classes. An explanation given by one of the headmasters for the

disparity in class-size was that it was easier to maintain discipline in a large class of girls than boys.

The selection was made with the intention of distinguishing between coeducational schools and single-sex schools. But, at the time of testing, it was discovered that with the exception of two urban schools, every high school had divided its students into classes by sex. So in effect, almost every high school student in Kerala is in a single sex environment in the classroom, if not always in the school. Although this de facto single-sex status of rural schools could have its implications for sex-related differences in achievement, for the purposes of this study, the distinction between single-sex and coeducational schools was collapsed.

Schools in Kerala, like those in other parts of India, have the choice of English or the native language as the medium of instruction. But this choice is operative almost entirely in urban areas. In the sample, all rural schools functioned in the medium of Malayalam, and a large number (80%) of the urban schools functioned in English.

The mean ages of the students at the different standard levels were: 13 years, 6 months for standard 9; and 9 years, 5 months for standard 5. There were no significant differences in age between the urban and rural samples.

Instruments of Testing

Test A for Grade 4 Level

Form 4C of the British Columbia Learning Assessment Study (Robitaille, 1981), with ten items deleted to make total of 36 items, was chosen for this level. The items deleted were: item 46 in Number and Operations, item 18 in Measurement of time, item 34 in Measurement of temperature, item 31 in monetary measure, items 19, 44 and 45 in Probability and items 5 and 24 in Computer Literacy. Where possible, names and contexts were changed to suit the local lifestyle (see Appendix III). Testing time was 35 minutes.

Test B for Grade 8 Level

A selection of 38 items from the Core Test and the four Rotated Forms in the Second International Mathematics Study of British Columbia of 1982 (Robitaille et al., 1982) was made. Names and contexts were changed where possible, as for Test A. The domains of testing were Algebra, Geometry, Measurement, Arithmetic, Ratio and Probability & Statistics (Appendix III). Testing time was 35 minutes.

No attempt was made to match the items on Test A or Test B with the Kerala syllabus in the subject (see Appendix II), as the primary objective was not a learning assessment of Kerala

schools, but an investigatation of sex-related differences when boys and girls from Kerala were faced with mathematical questions, familiar or otherwise.

The tests were translated into Malayalam with the help of the Textbook Department of the State Institute of Education. They were then translated back into English. The English versions of the tests are given in Appendix III.

Procedure

Schools in Kerala reopened after the summer vacation of two and a half months on June 16, 1983.[1] The tests were administered to all in the third week of classes, July 4-8.

Two members of the State Institute of Education and the investigator took charge of one district each. Each of the schools in the sample was visited by the member concerned and a meeting held with the head of the school and the teachers of the classes taking the tests. It was decided that no member should enter the classroom before or during testing, so that conditions remained normal. The tests were given, and collected by the class teachers. The investigator scored all the tests.

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[1]Schools ordinarily reopen after the summer break on June 1. The delayed monsoon and the attendant drought caused the date to be postponed. As it happened, the S.W.Monsoon which normally reaches the Kerala coast around June 1, did finally arrive -- on June 16.

Poor printing had caused some of the diagrams to be smudged and unclear.[1] As a result, item 29 of Test A, and items 13 and 35 of Test B were omitted. The mean percentage scores for the samples, with the omissions, by sex and location, were found to increase almost uniformly by about 1% leaving the difference in scores unaffected. The data presented in the following chapter are with the above mentioned items deleted.

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[1]Due to a combination of strikes in various sections of industry and a statewide cut on industrial use of power during the drought, the three major printing presses in the capital were closed indefinitely. As a result a lesser-known and less efficient private press had to be patronized.

Chapter 4

RESULTS

The scores on Test A and Test B were recorded by sex and location, and the percentage of subjects who scored correctly on each item (p-values) were calculated for each group. From the p-values on items obtained for each location, the percentage mean scores in each of the domains of testing were calculated by sex and compared. The results obtained are presented in this chapter.

Description of Sample

The distribution of subjects by sex in the urban and rural samples at the two grade levels, Grade 4 and Grade 8, are presented in Table 1.

Comparison of Mean Scores

Mean scores in the various domains of testing for the urban and rural samples at the two grade levels are presented in Tables 2-5. The percentage of subjects who scored correctly on each item in the two tests (p-values) are given in Appendix IV, Tables 6 & 7.

Urban Sample

Grade 4

At the Grade 4 level, boys outperformed girls in every domain of testing (Table 2). The largest difference of 15% was in Measurement, followed by 8% in Algebra and 5% each in Number and Operations, and in Geometry. In overall mean scores, boys outperformed girls by 7%.

Grade 8

At the Grade 8 level, boys outperformed girls in two domains: in Probability and Statistics by 4%, and in Ratio by 1% (Table 3). The performance of boys and girls were on a par in Geometry. In the remaining four domains, girls outperformed boys: by 11% in Fractions, 4% in Measurement, 4% in Arithmetic and 2% in Algebra. In overall mean scores, girls outperformed boys by 3%.

Rural Sample

Grade 4

At the Grade 4 level, boys and girls performed on a par in Measurement (Table 4). In the remaining three domains girls outperformed boys. The difference was 3% each in Number and Operations, and in Geometry, and 2% in Algebra. In overall mean scores girls outperformed boys by 2%.

Grade 8

At the Grade 8 level, both boys and girls performed equally poorly (28%) in Arithmetic, and in Ratio (Table 5). In the remaining five domains boys were ahead of the girls: by 16% in Algebra, 15% in Fractions, 10% in Measurement, 6% in Probability and Statistics, and 2% in Geometry. In overall mean scores, boys outperformed girls by 8%.

Table 1

Distribution of Subjects in Sample

Grade Level	Urban		Rural		Total
	Boys	Girls	Boys	Girls	
Grade 4	149	161	151	135	596
Grade 8	205	191	179	206	781
Total	354	352	330	341	1377

Table 2

Grade 4 Level: Urban Scores in Percentages by Domain

Domain	Boys	Girls	Difference Col.2 - Col.3
No. & Op. (17)[1]	64	59	5
Algebra (4)	37	29	8
Geometry (7)	49	44	5
Measurement (7)	54	39	15
Weighted Mean	56	49	7

[1] Numbers in parentheses in column 1 indicate the number of items in each domain.

Table 3

Grade 8 Level: Urban Scores in Percentages by Domain

Domain	Boys	Girls	Difference Col.2 - Col.3
Algebra (9)[1]	55	57	-2
Geometry (10)	44	44	0
Fractions (5)	44	55	-11
Measurement (4)	49	53	-4
Arithmetic (3)	46	50	-4
Probability & Statistics (3)	50	46	4
Ratio (2)	46	45	1
Weighted Mean	48	51	-3

[1] Numbers in parentheses in column 1 indicate the number of items in each domain.

Table 4

Grade 4 Level: Rural Scores in Percentages by Domain

Domain	Boys	Girls	Difference Col.2 - Col.3
No. & Op. (17)[1]	60	63	-3
Algebra (4)	43	45	-2
Geometry (7)	45	48	-3
Measurement (7)	53	53	0
Weighted Mean	54	56	-2

[1] Numbers in parentheses in column 1 indicate the number of items in each domain.

Table 5

Grade 8 Level: Rural Scores in Percentages by Domain

Domain	Boys	Girls	Difference Col.2 - Col.3
Algebra (9)[1]	46	30	16
Geometry (10)	34	32	2
Fractions (5)	41	26	15
Measurement (4)	41	31	10
Arithmetic (3)	28	28	0
Probability & Statistics (3)	36	30	6
Ratio (2)	28	28	0
Weighted Mean	38	30	8

[1] Numbers in parentheses in column 1 indicate the number of items in each domain.

Chapter 5

SUMMARY of RESULTS and IMPLICATIONS

A summary of the results of the study, its bearing on the "nature" and "nuture" positions on sex-related differences in mathematics achievement scores, and an alternative inference drawn from a post hoc analysis of the findings are presented in this chapter.

Findings

The findings in response to the stated objectives of this study were:

(1) In the urban sample, sex-related differences existed at each of the grade levels studied. At the Grade 4 level the difference was in favour of the boys by 7%; at the Grade 8 level the difference was in favour of the girls by 3%.

(2) In the rural sample, sex-related differences existed at each of the grade levels studied. At the Grade 4 level the difference was in favour of the girls by 2%;

at the Grade 8 level the difference was in favour of the boys by 8%.

Bearing of Findings on the "Nature-Nurture" Positions

At the Grade 4 level (9 year-olds), boys appear to have an appreciable advantage over girls in the urban setting while girls display a marginal advantage in the rural setting. If the former is considered to support a genetic theory of male superiority in mathematical ability, then girls in the rural setting must be assumed to function under some advantages, relative to girls in urban areas, that counteract the results of their genetic inferiority.

At the Grade 8 level (13 year-olds), boys appear to have an appreciable advantage over girls in the rural setting, and girls display a marginal advantage over boys in the urban setting. If the male superiority in rural areas is due to genetic superiority in male mathematical ability, then girls in urban areas must function under some advantages, relative to rural girls, that more than counteract their genetic inferiority.

As this study recorded no socio-psychological variables, the only unequivocal conclusion that can be arrived at on the basis of evidence from the samples considered is: If the "nature" position for sex-related differences in mathematics achievement scores holds, in the age group of 9-13 years, it is not beyond being remedied by factors that must constitute the

"nurture" position.

Alternative Inference from Findings

An alternative interpretation of the findings suggests itself when urban-rural differences in mean scores by sex are examined although such an analysis was not a stated objective of the study. At the Grade 4 level, the urban-rural difference in scores for boys is 2%, while that for girls is 7% (see Tables 2 & 4). At the Grade 8 level, the urban-rural difference for boys is 10%, while that for girls is 21% (see Tables 3 & 5). Together with the finding that girls achieve both the highest and the lowest mean scores at each grade level (at the Grade 4 level urban boys and rural girls share the highest standing), an apparently legitimate inference could be:

(1) that girls are not inferior to boys in mathematical ability, but

(2) that such exogenous factors as tend to inhibit, or depress, mathematics achievement scores, as is evident in the urban-rural differences, have a greater effect on girls than boys.

Limitations of the Study

This study was designed largely as an exploratory study in sex-related differences in mathematics achievement scores in an area where no such study had been undertaken. The existence of

sex-related differences in favour of boys in one sample, and in favour of girls in another, both of the same age and grade level, differing only by locale, indicate that exogeneous data on socio-economic, cultural and instructional variables need to be considered, and may be expected to shed light on the issue.

Suggestions for Further Research

Replication of the study in other districts of Kerala, and in other parts of India may serve to establish a more consistent pattern of sex-related differences in mathematics achievement scores between urban and rural locations. If, on the other hand, the results of this study are repeated, it may indicate that reasons for sex-related differences in mathematics achievement scores are to be found, not in genetic differences in ability, but in:

(1) Differences in educational variables such as class-size, teacher qualifications, educational objectives, study habits of children or medium of instruction, and their interaction with sex.

(2) Differences in socio-psychological factors between urban and rural areas such as motivation, desire for upward social mobility in girls, eroding of traditional values/inhibitions in relation to girls in urban areas.

(3) Differences in socio-economic status and parental literacy in relation to urban and rural areas and their interaction with

sex.

Studies in these areas in urban and rural Kerala may further explain some of these issues on sex-related differences in mathematics achievement scores.

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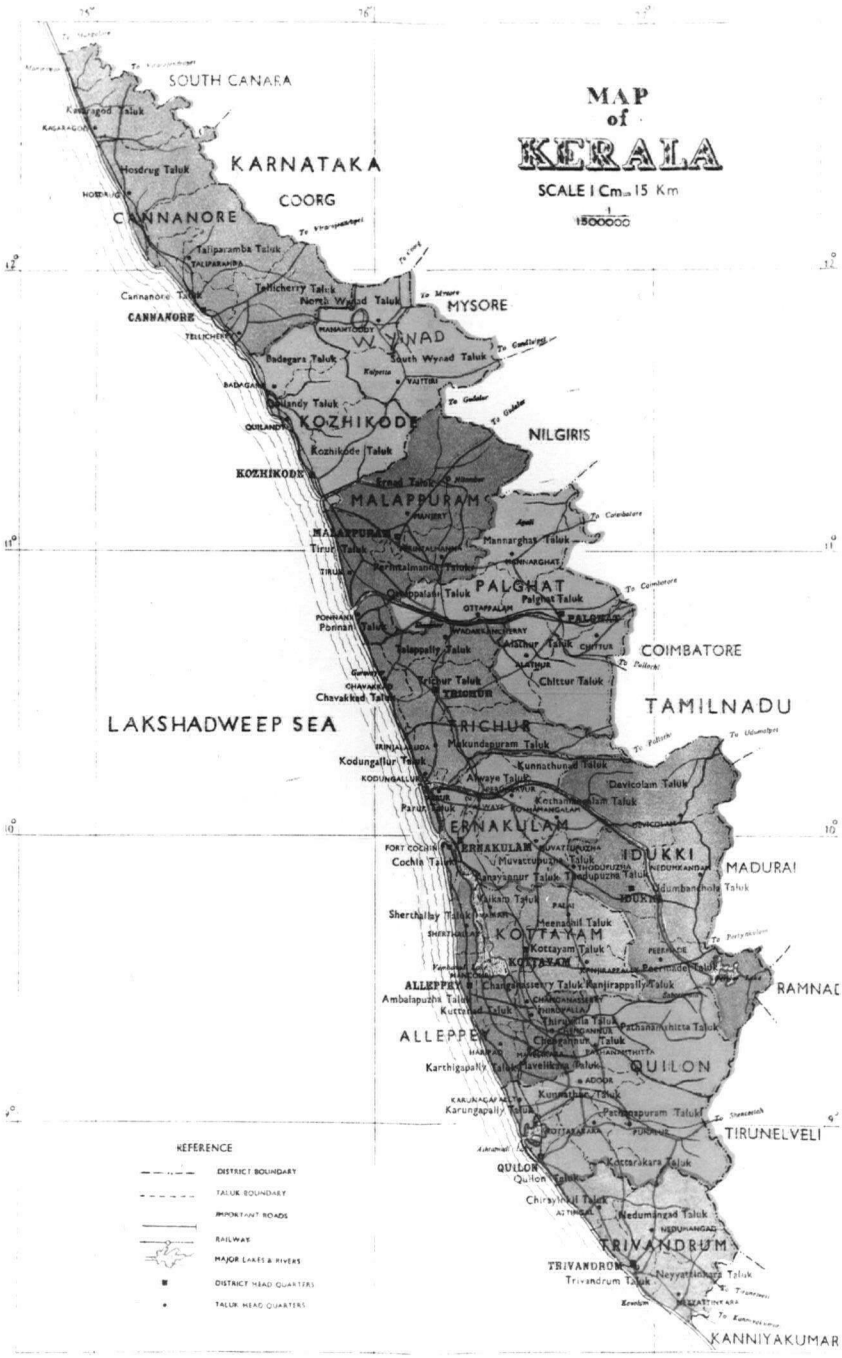
APPENDIX I

Map of Kerala


MAP
of
KERALA
SCALE 1 Cm = 15 Km
1/1500000
SOUTH CANARA
KARNATAKA
COORG
CANNANORE
MYSORE
WYNAD
KOZHIKODE
NILGIRIS
MALAPPURAM
PALGHAT
COIMBATORE
TAMILNADU
LAKSHADWEEP SEA
TRICHUR
ERNAKULAM
IDUKKI
MADURAI
KOTTAYAM
ALLEPPEY
RAMNAD
QUILON
TIRUNELVELI
TRIVANDRUM
KANNIYAKUMAR
REFERENCE
DISTRICT BOUNDARY
TALUK BOUNDARY
IMPORTANT ROADS
RAILWAY
MAJOR LAKES & RIVERS
DISTRICT HEAD QUARTERS
TALUK HEAD QUARTERS

APPENDIX II

Syllabus in Mathematics for Kerala Schools

Standard IV

	No. Of periods.
1. Diagnostic testing and remedial teaching.	55
2. Numbers up to those having nine digits.	15
3. Multiplication.	35
4. Division.	35
5. Problems involving the four fundamental operations.	20
6. Number-line.	10
7. Fractions.	25
8. Decimal Fractions.	45
9. Measurement of Time.	15
10. Pictorial Diagrams.	10
11. Recognition of Geometrical shapes and figures.	10
12. Discovering Patterns.	5
Total...	280

Standard VIII

	No. Of hours.
1. Sets, Venn diagrams, operations.	20
2. Real Numbers.	10
3. Approximate Numbers, their precision and accuracy.	15
4. Always-true sentences.	20
5. Open sentences in one variable.	22
6. Open sentences in two vriables.	22
7. Basics concepts in Geometry.	26
8. Triangles and Perpendiculars.	15
9. Triangles (continued).	15
Discerning Patterns.	10
	Total...175

APPENDIX III

Instruments of Testing

TEST A

(Grade 4 level)

1. Subtract:

86-
22
——

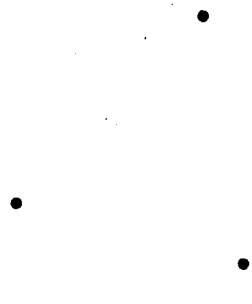
64.....□
68.....□
54.....□
118.....□
I don't know.....□

2. Add:

678+
9+
34
——

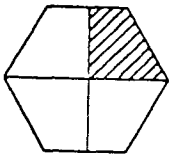
901.....□
991.....□
621.....□
721.....□
I don't know.....□

3. If you connected these three dots with straight lines what shape would you get?

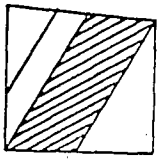


Square.....□
Rectangle.....□
Triangle.....□
Circle.....□
I don't know.....□

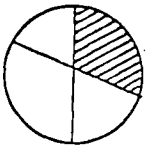
4. Which shows 1/4 shaded?



.....□



.....□



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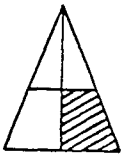
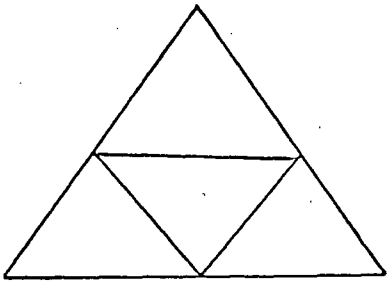


.....□

I don't know.....□

5. How many triangles are shown here?



1.....□

3.....□

5.....□

9.....□

I don't know.....□

6. If one child needs two books, how many books do three children need?

3.....□

6.....□

8.....□

9.....□

I don't know.....□

7. 10 tens = One _____

million...□

thousand...□

ten...□

I don't know..□

8. A box contains 2 blue pens, 4 red pens and 1 black pen. Vinod could not decide whether he wanted a red pen or a blue pen. He closed his eyes and picked one from the box. Which colour is he more likely to pick?

blue or black.....□

red.....□

blue.....□

black.....□

I don't know.....□

9. Which unit should be used to measure the length of a house?

millimetres.....□

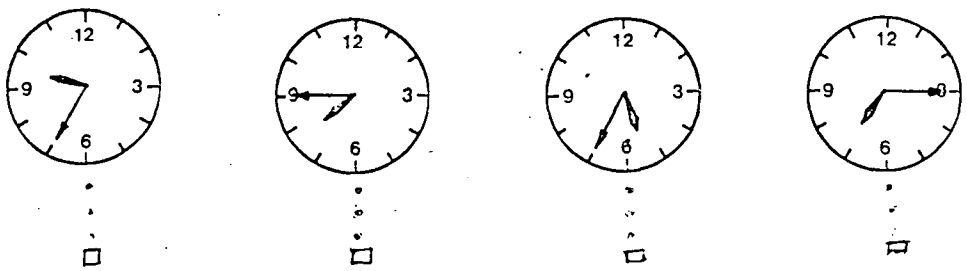
centimetres.....□

metres.....□

kilometres.....□

I don't know.....□

10. Jane finished her homework at 7:45. Which clock shows this time?



I don't know....□

11. What is the remainder in the following division problem?

$$\begin{array}{r} 9 \\ 3\overline{)\,28} \\ 27 \\ \hline 1 \end{array}$$

28...□

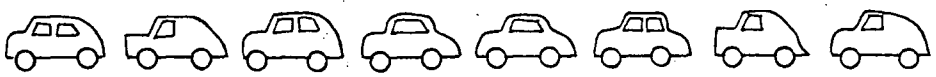
9...□

3...□

1...□

I don't know.....□

12. Eight cars are parked on a road. 1/4 of the cars are new. How many cars are new?



1...¤

2...¤

3...¤

4...¤

I don't know.....¤

13. Counting by 10s, the next three numbers are:

780, 700, ¤, ¤, ¤,

791, 792, 793....¤

720, 730, 740....¤

800, 810, 820....¤

800, 801, 802....¤

I don't know.....¤

14. Round 1368 to the nearest hundred:

1300...¤

1400...¤

3000...¤

4000...¤

I don't know.....¤

15. It was a cold rainy day. When John looked at the thermometre, it showed:

23° C...□

34° C...□

3° C...□

16° C...□

I don't know.....□

16. Which number says four thousand two hundred sixty five?

42065...□

5624...□

40265...□

4265...□

I don't know.....□

17. A hippopotamus weighs 1153 kg., an elephant weighs 1127 kg, a buffalo weighs 1196 kg,and a giraffe weighs 1183 kg. Rounding to the nearest 100 kg, which weighs closest to 1100 kg?

hippo...□

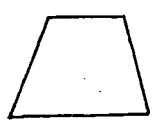
elephant...□

buffalo...□

giraffe...□

I don't know.....□

18. In which figure are all angles the same size?



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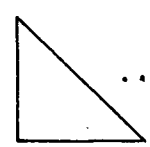

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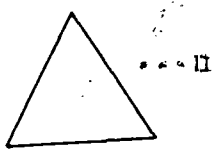
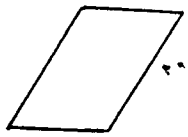


...□



...□

I don't know.....□

19. Chandran took twelve rupees to buy stamps. He bought 6 stamps at 8 paise each, 8 stamps at 3 paise each and 5 stamps at 25 paise each. How much did he spend on stamps?

Rs. 10.03...□

Rs. 0.55...□

Rs. 1.97...□

Rs. 13.97...□

I don't know.....□

20. Which number or numbers can go into the blank to make this number sentence TRUE?

5 + ( ) <12

7...□

any number less than 7...□

any number greater than 7...□

no number.....□

I don't know.....□

21. Which is the smallest number that can be made using all the digits 4, 3, 9, 1?

1934...□

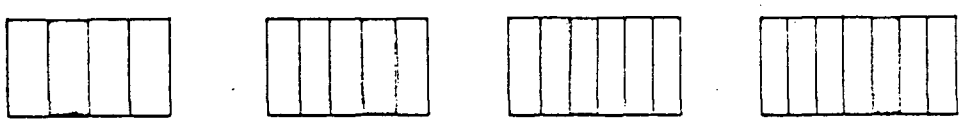
1439...□

1349...□

1943...□

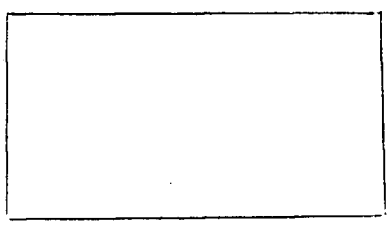
I don't know.....□

22. Which box is 1/5 (one-fifth) shaded?



I don't know.....□

23. How many lines of symmetry does this shape have?



1...□

2...□

3...□

4...□

I don't know.....□

24. 156 rounded to the nearest 10 is:

160...□

170...□

150...□

140...□

I don't know.....□

25. John put a wire fence round his rectangular garden. The garden is 10 metres long and 6 metres wide. How many metres of fencing did he use?

16...□

32...□

36...□

60...□

I don't know.....□

26. How many centimetres are there in one metre?

1...□

10...□

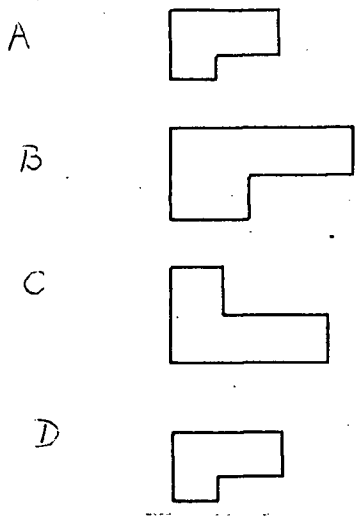
100...□

1000...□

I don't know....□

27. Figures that are the same size and shape are congruent

figures. Which of the following are congruent?



A and B...□

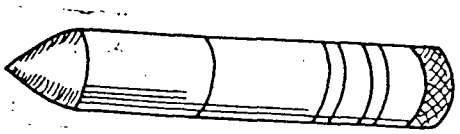
A and D...□

C and D...□

B and C...□

I don't know...□

28. About how long is this pencil?



1 centimetre....□

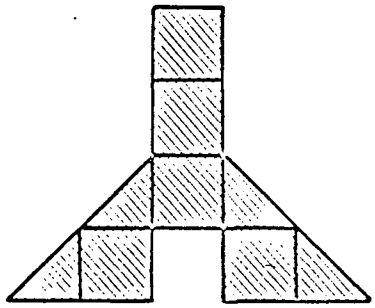
5 centimetres...□

1 metre...□

10 metres...□

I don't know...□

29. What is the area of this shape in square centimetres?



1 cm^2

7...□

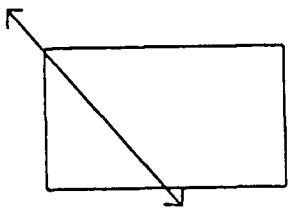
12...□

9...□

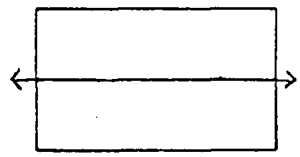
5...□

I don't know....□

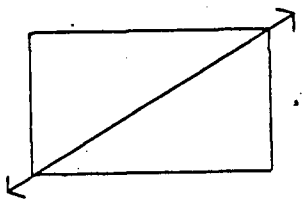
30. In which figure is the line a line of symmetry?



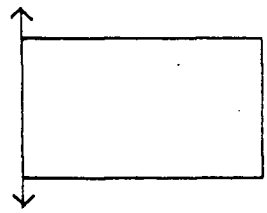
...□



...□



...□



...□

I don't know...□

31. A bottle of milk is likely to hold:

1 millilitre...□

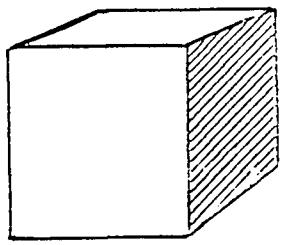
10 millilitres...□

1 litre...□

100 litres...□

I don't know...□

32. One face is shaded on this cube. How many faces does the cube have?



3...□

6...□

8...□

12...□

I don't know...□

33. Which is true?

35 = 30 + 5 .....□

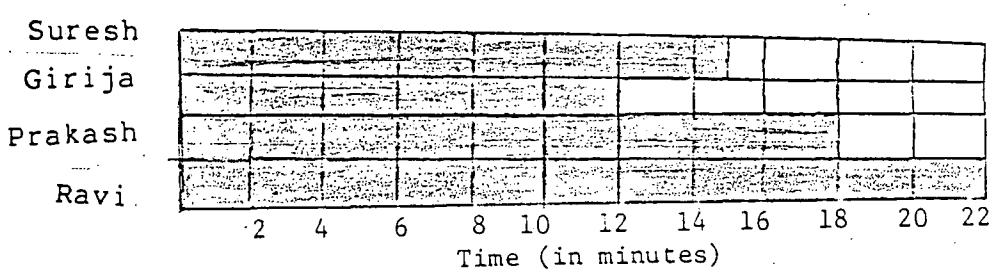
35 > 30 + 5 .....□

35 > 5 + 30 .....□

30 + 5 < 35 .....□

I don't know....□

34. Santhosh was testing his model plane. Four of his friends given below, guessed as to how long it would stay in the air. The plane stayed up for 17 minutes. Who guessed closest to the correct time?



Suresh...□

Prakash...□

Girija...□

Ravi...□

I don't know...□

35. Madhu has 51 soda bottles and 8 wooden boxes. Each box holds 6 bottles. If Madhu fills all the boxes, how many bottles will there be left over?

6...□

8...□

3...□

14...□

I don't know...□

36. Madhu distributed 51 soda-filled bottles to the shops. He collected back 30 of the empty bottles. His sister Leela collected the rest. How many bottles did Leela collect?

18...□

14...□

21...□

44...□

I don't know....□

TEST B

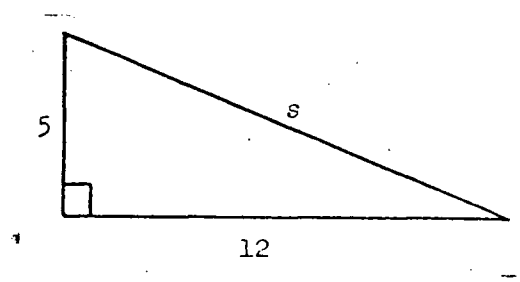
(Grade 8 level)

1. Which of the following sequences of numbers is in the order in which they occur from left to right on the number line?

(a) {0, 1/2, -1}; (b) {0, -1, 1/2 }; (c) {-1, -1/2, 0}
(d) {-1, 0, 1/2}; (e) {-1/2, -1, 0}

Ans : _____

2. What is the value of 's'?



(a) 7; (b) 13; (c) 15
(d) 17; (e) None of these.

Ans : _____

3. Suma walked from her house to the railway station which is 3.1 kilometres away. During her walk she lost her watch, went back 1.7 kilometres to find it, and then continued in the original direction until she reached the railway station. How many kilometres had Suma walked altogether when she arrived at the railway station?

(a) 1.4; (b) 4.8; (c) 6.5

(d) 8.2; (e) None of these.

Ans : _____

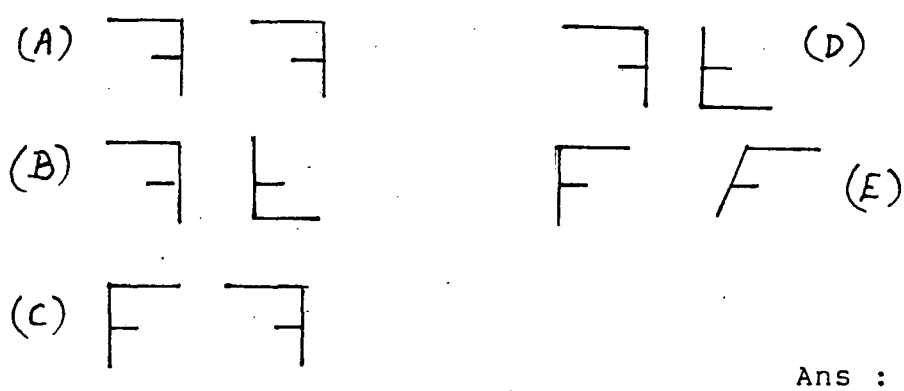
4. (-2) x (-3) is equal to:

(a) -6; (b) -5; (c) -1;

(d) 5; (e) 6

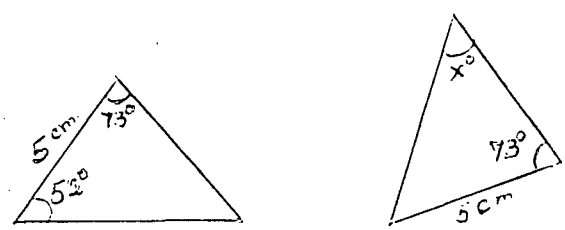
Ans : _____

5. In which diagram below is the second figure the image of the first figure under a reflection in a line?



Ans : _____

6.



The triangles shown above are congruent. The measures of some

sides and angles are shown. What is x?

(a) 52; (b) 55; (c) 65;

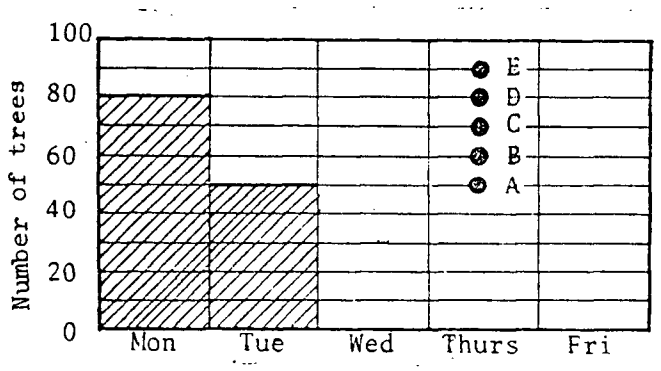
(d) 73; (e) 75.

Ans : _____

7. The following table shows the number of trees planted along a highway in a week.

Day	Mon.	Tues.	Wed.	Thurs.	Fri.
No. of Trees	80	50	60	90	75

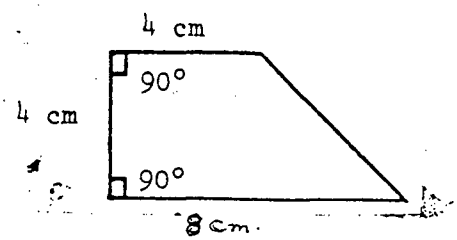
On the diagram below the graph for the first two days' planting has been drawn. If the graph was completed, which point would indicate the top of the graph on Thursday?



(a) A; (b) B; (c) C; (d) D; (e) E.

Ans : _____

8.

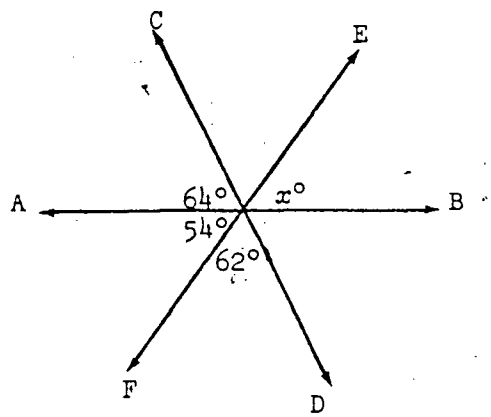


There is a brass plate of the shape and diensions shown in the figure above. What is its area in square centimetres?

(a) 16; (b) 24; (c) 32; (d) 64; (e) 96.

Ans : _____

9.



AB, CD and EF are concurrent. The measures of certain angles are shown. What is the value of x?

(a) 54; (b) 62; (c) 64; (d) 126; (e) 128;

Ans : _____

10. Simplify: $5x + 3y + 2x - 4y$

(a) $7x + 7y$; (b) $8x - 2y$; (c) $6xy$;

(d) 7x - y; (e) 7x + y.

Ans : _____

11. What is the volume of a rectangular box with interior dimensions 10 cm long, 10 cm wide, and 7 cm high?

(a) 27 cc; (b) 70 cc; (c) 140 cc;
(d) 280 cc; (e) 700 cc.

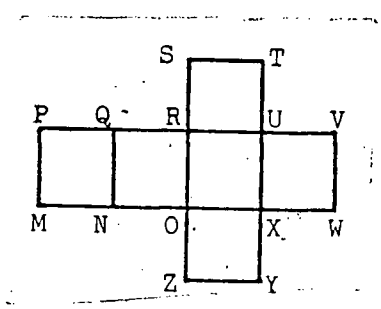
Ans : _____

12. If P=LW and if P=12 and L=3, then W is equal to

(a) 3/4; (b) 3; (c) 4; (d) 12; (e) 36.

Ans : _____

13.



The diagram shows a cardboard cube that has been cut along some edges and flattened out. If it is folded up again into a cube, which two corners will touch at corner P?
(a) Q and S; (b) T and Y; (c) W and Y;
(d) T and V; (e) U and Y.

Ans. : -----

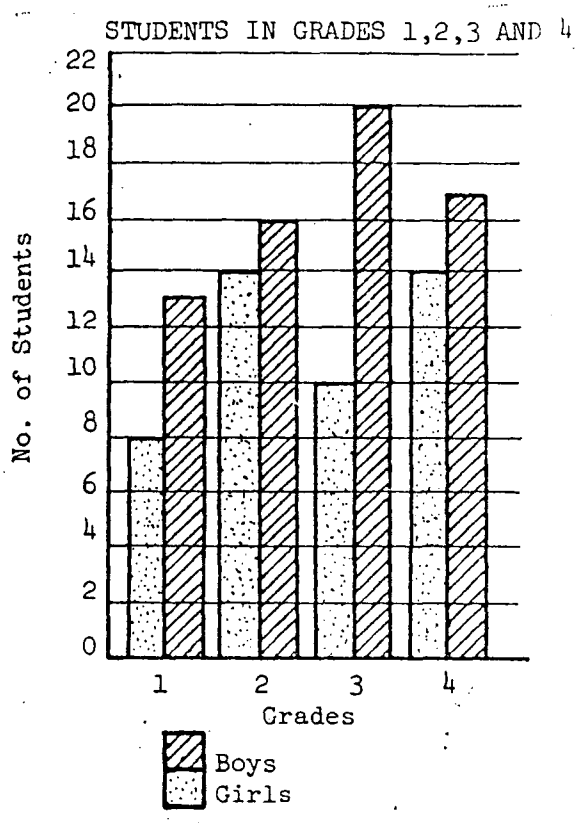
14. Which of the following is a pair of equivalent fractions?

(A) 5/8, 2/3; (b) 5/6, 2/3; (c) 4/5, 14/15;

(d) 3/5, 9/15; (e) 1/2, 14/24.

Ans : _____

15. Which of these is a TRUE statement about the information shown on the graph?



(a) Standard 2 is the smallest class.

(b) Standards 2 and 4 have the same number of students.

(c) Standard3 has twice as many boys as girls.

(d) Standard 4 has more girls than boys.

(e) Standard 1 has as many boys as there are girls in Standard 4.

Ans : _____

16. Q={ 1, 2, 3, 4, 5, 6, 7, 8, 9 }

R={ 3, 5, 7, 9, 11, 13 }

$S=Q \cap R$

There are 9 elements in set Q and 6 in set R. How many elements are there in set S?

(a) 16; (b) 11; (c) 7; (d) 4; (e) 2.

Ans : _____

17. 2/5 + 3/8 is equal to

(a) 5/13; (b) 5/40; (c) 6/40; (d) 16/15; (e) 31/40.

18. 0.40 x 6.38 is equal to

(a) .2552; (b) 2.452; (c) 2.552;
(d) 24.52; (e) 25.52.

Ans : _____

19. On level ground, a boy 5 units tall casts a shadow 3 units long. At the same time, a nearby telephone pole 45 units high casts a shadow, the length of which in the same units is

(a) 24; (b) 27; (c) 30; (d) 60; (e) 75.

Ans : _____

20. If $6x - 3 = 15$

then $6x = 15 - 3$ (i)

and $6x = 12$ (ii)

and $x = 12/6$ (iii)

$x = 2$ (iv)

If there is an error in the above reasoning, it first occurs in

(a) (i); (b) (ii); (c) (iii); (d) (iv); (e) None of these.

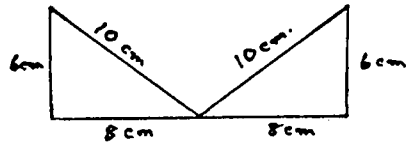
Ans : _____

21. The value of $2^3 + 3^2$ is

(a) 30; (b) 36; (c) 64; (d) 72; (e) None of these.

Ans : _____

22.



The total area of the two triangles is, in square centimetres

(a) 6 x 8; (b) (6 x 8)/2; (c) (10 x 6)/2;

(d) (16 x 12)/2; (e) (20 x 12)/2.

Ans : _____

23. A bottle of soda, including the price of the bottle, costs a paise, but there is a refund of b paise on each empty bottle returned. How much will Gopi have to pay for x bottles if he brings back y empty bottles.

(a) ax + by paise; (b) ax - by paise; (c) (a - b)x paise; (d) (a+x) - (b+y) paise; (e) None of these.

Ans : _____

24. In a school of 800 pupils, 300 are boys. The ratio of the number of boys to the number of girls is

(a) 3 : 8; (b) 5 : 8; (c) 3 : 11; (d) 5 : 3; (e) 3 : 5.

Ans : _____

25. The arithmetic mean (average) of 1.50, 2.40, 3.75, is equal to

(a) 2.40; (b) 2.55; (c) 3.75; (d) 7.65; (e) None of these.

Ans : _____

26. A quadrilateral MUST be a parallelogram if it has

(a) One pair of adjacent sides equal.

(b) One pair of parallel sides.

(c) A diagonal as axis of symmetry.

(d) Two adjacent angles equal.

(e) Two pairs of parallel sides.

Ans : _____

27. One of the following points can be joined to the point (-3, 4) by a line segment which cuts NEITHER the x, NOR the y axis. Which one?

(a) (-2, 3); (b) (2,-3); (c) (2, 3);

(d) (-2,-3); (e) (4,-3).

Ans : _____

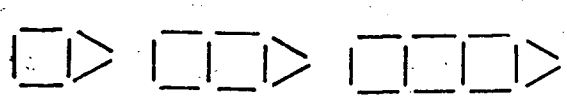
28. Which of the following is the most likely to be nearest to the weight of a normal man?

(a) 8.5 kg; (b) 85 kg; (c) 185 kg;

(d) 850 kg; (e) 1850kg.

Ans : _____

29. Matchsticks are arranged as follows:

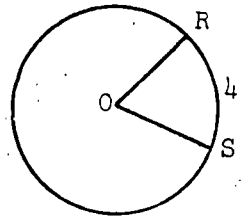


If the pattern continued, how many matchsticks are used in making the 10th figure?

(a) 30; (b) 33; (c) 36; (d) 39; (e) 42.

Ans : _____

30. The length of the circumfrence of the circle with centre at O is 24, and the length of the arc RS is 4. What is the central angle ROS to the nearest degree?



(a) 24; (b) 30; (c) 45; (d) 60; (e) 90.

Ans : _____

31. 30 is 75% of what number?

(a) 40; (b) 90; (c) 105; (d) 225; (e) 2250.

Ans : _____

32. What is the square root of 12 x 75?

(a9 6.25; (b) 30; (c) 87; (d) 625; (e) 900.

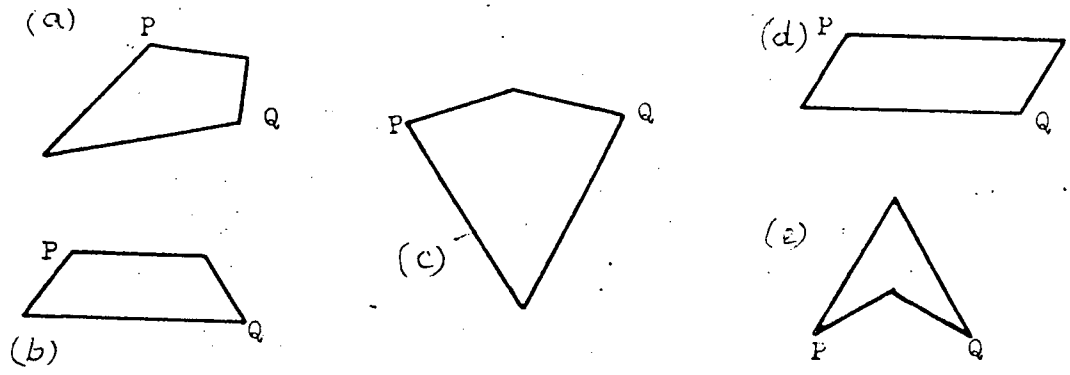
Ans : _____

33. In the number 847.36, the digit 6 represents

(a) 6x1/100; (b) 6x1/10; (c) 6x1; (d) 6x10; (e) 6x100

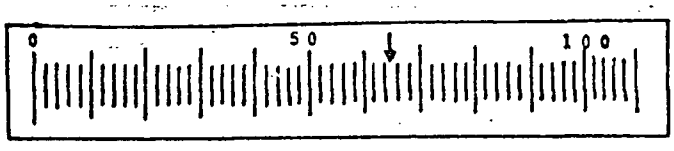
Ans : _____

34. If the segment PQ were drawn for each figure shown below, it would divide one of the figures into two congruent triangles. Which figure?



Ans : _____

35.



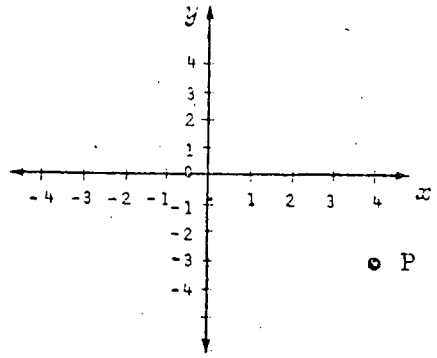
On the scale the reading indicated by the arrow is between

(a) 51 and 52; (b) 57 and 58; (c) 60 and 62;

(d) 62 and 64; (e) 64 and 66.

Ans : _____

36.



What are the coordinates of P?

(a) (-3, 4); (b) (-4,-3); (c) (3, 4);

(d) (4,-3); (e) (-4, 3).

Ans : _____

37. The table below gives the relation between the height from which a ball is dropped (d), and the height to which it bounces (b).

d	50	80	100	150
b	25	40	50	75

Which formula describes this relation?

(a) $b = d^2$; (b) $b = 2d$; (c) $b = d/2$;

(d) $b = d + 25$; (e) $b = d - 25$.

Ans : _____

38. The air temperature at the foot of a mountain is 31 degrees. On top of the mountain the temperature is -7 degrees. How much

warmer in degrees is the air at the foot of the mountain?

(a) -38; (b) -24; (c) 7; (d) 24; (e) 38.

And : _____

Appendix IV

Tables of Results by Item

Table 6

Itemwise p-values on Test A at Grade 4 Level.

Item No.	Urban Kerala Boys	Urban Kerala Girls	Urban Kerala Diff.	Rural Kerala Boys	Rural Kerala Girls	Rural Kerala Diff.
1.	96	96	0	85	90	-5
2.	93	89	4	66	79	-13
3.	79	57	22	79	72	7
4.	70	68	2	72	64	8
5.	37	29	8	43	55	-12
6.	90	84	6	73	90	-17
7.	77	81	-4	80	80	0
8.	50	40	10	64	64	0
9.	55	34	21	48	57	-9
10.	69	46	23	57	50	7
11.	94	78	16	74	95	-21
12.	30	19	11	52	40	12
13.	84	68	16	72	77	-5
14.	36	35	1	29	22	7
15.	44	38	6	58	41	17
16.	59	56	3	42	51	-9
17.	48	25	23	62	57	5
18.	50	55	-5	60	64	-4
19.	56	28	28	58	47	11
20.	35	17	18	29	30	-1
21.	64	65	-1	63	64	-1
22.	64	68	-4	52	66	-14
23.	26	21	5	25	25	0
24.	42	37	5	37	40	-3
25.	25	5	20	39	42	-3
26.	60	51	9	62	57	5
27.	63	55	8	36	41	-5
28.	60	30	30	50	50	0
30.	30	34	-4	27	23	4
31.	66	71	-5	58	73	-15
32.	61	58	3	47	59	-12
33.	47	43	4	41	38	3
34.	16	16	0	37	46	-9
35.	35	34	1	40	55	-15
36.	53	61	-8	64	51	13

Note. Diff. = p-value for Boys - p-value for Girls.

Table 7

Itemwise p-values on Test B at Grade 8 Level

Item No.	Urban Kerala Boys	Urban Kerala Girls	Urban Kerala Diff.	Rural Kerala Boys	Rural Kerala Girls	Rural Kerala Diff.
1.	84	77	7	82	49	33
2.	31	39	-8	29	27	2
3.	43	34	9	59	22	37
4.	83	83	0	63	33	30
5.	69	45	24	34	37	-3
6.	49	47	2	55	34	21
7.	76	67	9	37	41	-4
8.	28	22	6	44	25	19
9.	69	68	1	40	37	3
10.	45	64	-19	35	21	14
11.	75	84	-9	56	36	20
12.	79	83	-4	38	35	3
14.	67	84	-17	53	34	19
15.	55	47	8	38	33	5
16.	74	71	3	58	37	21
17.	39	51	-12	19	19	0
18.	48	57	-9	34	33	1
19.	51	28	23	39	26	13
20.	39	39	0	35	30	5
21.	75	66	9	21	27	-6
22.	18	24	-6	20	21	-1
23.	31	41	-10	32	22	10
24.	50	47	3	15	25	-10
25.	18	24	-6	32	16	16
26.	50	62	-12	35	46	-11
27.	13	19	-6	17	22	-5
28.	73	80	-7	43	41	2
29.	36	48	-12	32	34	-2
30.	35	34	1	30	21	9
31.	42	42	0	40	30	10
32.	27	36	-9	30	22	8
33.	23	47	-24	39	24	15
34.	39	61	-22	32	32	0
36.	31	39	-8	30	36	-6
37.	28	37	-9	47	19	28
38.	30	15	15	20	25	-5