THE ACQUISITION OF SOME GEOMETRICAL CONCEPTS AMONG KIKUYU PRIMARY SCHOOL CHILDREN.

BY

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A THESIS

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This thesis is my original work and has not been presented for a degree in any other university.

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Abstract

The aim of this study was to investigate some variables that influence the acquisition of the concepts of length, area, and internal volume. Precisely, the effect of age as measured by grade, and sex were studied. The study also attempted to find out whether length, area, and internal volume conservation were mastered concurrently.

The sample used for this study consisted of 15 boys and 15 girls from each of standards one, three, five and seven, making a total of 120 subjects in all. These children ranged in age from six to fifteen years. All of the subjects attended a rural primary school in Kiambu District.

The conservation of area tasks were administered first, followed by length and internal volume. All the tasks were administered by the investigator herself in Kikuyu language. The tasks were given individually, to all the subjects in September and October, 1973.

Based on Piaget's line of theorizing, it was predicted that:

(i) Older children in higher grades (standard 5 and 7) would perform better on these conservation tasks than younger children in lower grades (standards 1 and 3).

(ii) Conservation of the three geometrical concepts would be concurrent.

(iii) Boys would perform better than girls in all grades.

The obtained results indicated that older children performed significantly better than younger children, boys performed significantly better than girls, and finally, length was found to be an earlier acquisition than area and internal volume among girls. Among boys, on the other hand, length was only an earlier acquisition than internal volume. For both groups of boys and girls, area and internal volume were mastered at the same time. Thus, the hypotheses that older children would perform better than younger children and that boys would perform better than girls were confirmed. There was little support for the hypothesis that length, area and internal volume would be mastered concurrently.

CHAPTER ONE

INTRODUCTION

The study of intellectual development is of utmost importance to educational psychologists and to others who are interested in the welfare of children. Such a study is necessary before appropriate curricula and suitable teaching methods can be designed that would be suitable for children at various stages of conceptual development. Realization of its importance has aroused a great deal of interest in the development of children's thought processes. The greatest quantity of work on intellectual development and children's thought processes comes from Jean Piaget, a swiss psychologist.

Piaget's theoretical framework

Piaget has claimed that intellectual development goes through a number of stages (Flavell, 1963). These stages include, the sensori - motor stage (0 - 2 years), the pre-conceptual thought stage (2 - 4 years), the intuitive phase (4 - 7 years), the stage of concrete operations (7 - 11 years), and the stage of formal operations (11 years and over).

During the sensori-motor stage, the child differentiates himself from objects and establishes a beginning of the awareness of cause and effect, of time and of space. The formation of cognitive structures or schemas begins at this time. Each schema is an organisation of particular behavious, all relevant to one another. Cognitive structures are developed through the processes of accommodation and assimilation. The child's intellectual development proceeds by the assimilation of new information. This, in turn, results in the modification of existing structures. Possession of modified structures results in an altered behaviour towards the environment.

During the pre-conceptual thought stage (2 - 4 years), the child experiences the development of symbolic thought, with language playing an increasing role in intellectual development, and in the socialization of the child. The child is typically egocentric and is unable to take the viewpoint of others. Things are judged at face value and thought is not reflective.

This stage is followed by the intuitive phase (4 - 7 years). This phase is marked by increased symbolic functioning, the ability to deal with some relationships and to handle number concepts. However, thought is still dominated by perception since the child's organisation, classification, and primitive conceptions, are determined, to a large extent, by the potency of the physical attributes, and usually, one aspect, dimension, or relation is considered at the expense of the others.

The intuitive phase is followed by the stage of concrete operations (7 - 11 years). Reasoning processes begin to appear logical. Mental acts, or operations, are fully developed, that is, are internalized and reversible. This development enables the child to understand that certain properties of objects are invariant regardless of certain transformations.

For example, the child recognises that two rods of identical length remain equal in length in spite of the fact that one of them is bent. This awareness is called conservation. In Piagets' theory, this schema of conservation represents a pivotal construct in the child's cognitive transition from the pre-operational stage to the stage of concrete-operational thought. It enables the child to rely more on abstract concepts as quantity, weight, length, or area and relatively less on such specific attributes of the stimulus objects as form or shape (wallach, 1963).

In the final stage of intellectual development, the child has acquired a capacity for abstract thought, can conceptualize and reason by hypotheses. For example, he can deduce that John is taller than Kamau when he is presented with the statement that John is taller than Komu and Komu is taller than Kamau. Before this stage is reached, the child could not arrive at this conclusion unless the persons whose height is to be compared were actually present.

In the stage of formal operations, the child can be guided by the form of various arguments. He can now ignore content and operate on what is called the hypothetico-deductive procedure of logical thought, since he can now formulate hypotheses and deduce logical conclusions (Flavell, 1963; Hoffman and Hoffman, 1964).

According to this theory of intellectual development, each new level is a new coherence, a new structuring of elements which until that time have not been systematically related to each other (Flavell, 1963; Duckworth, 1964).

These structures are governed by laws applying to the system as a whole, for example, the laws of reversibility and compensation. Reversibility refers to a simple returning to the starting point by undoing an operation that has just been performed. Compensation is the logical multiplication of relations and depends on the understanding of the reciprocity of two relevant dimensions, for example, the length and breadth of an area. Reciprocity refers to the fact that as length increases, width declines in order to maintain a constant area (Bruner, et al, 1966, pp 208-210).

Piaget (1952) implies that conservation is essential for adaptation to a fast changing world when he says that a highly developed technology can evolve only with the ability to conserve as the most rational thought is dependant upon it. He has demonstrated the acquisition of conservation of various concepts. However, now only a brief review of his formulations in relation to the acquisition of Euclidean concepts will be provided. It is hoped that this review will provide the theoretical background to the present study. The details of these formulations are available in chapter two.

Conservation of Euclidean Entities

According to Piaget, Inhelder and Szeminska (1960), the acquisition of conservation of Euclidean entities like length, distance, angles, rectangular co-ordinates and internal volume is completed during substage 3a, that is, between seven and eight years of age. From this period onwards, children understand that conservation is logically necessary because they can bring into a single whole, stationary sites and the objects (contained) which are moved from one place to another. The processes of subdivision and change of position are co-ordinated but are not fused till substage 3b when their fusion facilitates unit iteration.

According to this theory of development, conservation of length, area, and internal are concurrent acquisitions since they are dependent on the same infra-logical or spatial temporal operations of subdivision and change of position. However, it is not clear whether Piaget, et al, 1960, based this hypothesis on data obtained from the same sample or from comparable samples.

Some Validation Studies

Piaget's work on conservation has both stimulated a great deal of interest and raised a lot of criticisms (Flavell, 1963; Duckworth, 1964; Beilin, 1969). His procedures have been attacked for being too flexible and unsystematic. Besides, he does not always give complete information on the number and he age of the subjects or their exact performance.

Piaget employed the 'clinical' method and in it little attempt was made to control such variables as sex, intelligence, emotional states, and such cultural factors as language, schooling, and rural - urban residence.

His findings seem to be based on a combination of groups of subjects whose number or exact ages is seldom disclosed.

Again, Piaget does not always employ statistical procedures to his results in an attempt to validate them. He usually uses highly technical language and does not always explain exactly what he means.

Despite these criticisms, his work has attracted many researchers. His work has been replicated in different cultural settings (Lovell, Healey and Rowland, 1962; Goodnow, 1962; Goodnow and Bethon, 1966; Greenfield, 1966; Vernon, 1969; Otaala, 1970; Page, 1973; Lester and Klein, 1973). These investigators tend to find much the same sequence of stages of information about the development of conservation among African children. Results of these studies seem to suggest that although the sequence of development is similar to that found in western children, the rates of development differ. Results also vary from one African group to another. Such differences suggest need for more studies among other african societies to increase our understanding of conceptual development among african children.

In addition, the studies conducted to date largely deal with number and substance conservation(Price-Williams, 1961, Almy, 1966, Greenfield, 1966; Beard, 1968; Otaala, 1970; Lloyd, 1971; Ohuche, 1971). Less attention has been given to spatial and geometrical concepts (Beard, 1968; Vernon, 1969; Okonji, 1970; Omari, 1972; Page 1973). Greater developmental lags have been reported by these latter investigators. Thus, more research in this field might provide some important information about the development of these concepts.

The present study was, therefore, designed to investigate whether older (standards 5 and 7) Kikuyu primary school children would perform better on conservation of length, area and internal volume tasks, than younger children (standards 1 and 3). The study was also intended to investigate whether mastery of length, area, and internal volume conservation was concurrent. Finally, the study attempted to find out if boys would perform better than girls on conservation of length, area, and internal volume, in view of the fact that among the rural Kikuyu community girls seem to have less time for play have to perform more strenous tasks than boys and their freedom to wander away from home and mix outsiders is more restricted. It had previously been speculated that these factors could have adverse effects on girls' performance in intellectual tasks (Castle, 1966, pp 138 - 139).

Significance of the problem

The present study might provide useful information about the development of the concepts of length, area, and internal volume among Kikuyu primary school children. This information might aid curriculum designers to know the optimum time to introduce concepts related to Euclidean geometry. This is important in view of the fact that concepts of length, area and internal volume, are used widely in a number of school subjects.

Hypotheses

Working within Piaget's theoretical framework, as well as the other studies that had been provided and the differences in activities between rural Kikuyu boys and girls that had been observed, the following predictions were advanced:-

1. Children in higher standards (5 and 7) would perform better than children in lower standards (1 and 3).
2. Conservation of length, area and internal volume would be concurrent.
3. Boys would perform better than girls on conservation of length, area, and internal volume.

CHAPTER TWO

A REVIEW OF RELATED LITERATURE

Introduction:

According to Piaget (1952) conservation is a necessary condition for all rational activity. Therefore, research on its development is beneficial to those interested in educating children. The study of the development of reasoning or rational activity is largely a matter of analysing how the invariance of different properties is first gradually extended to situations in which the perceptual arrangement of parts is limited, and then generalized to all possible transformations, and later recognised as self-evident. Such studies would help in the assessment of intellectual development of children.

Piaget and his colleagues have illustrated the development of conservation in various fields, including, number, substance, weight, and such geometrical entities as length, distance, volume, area, and rectilinear co-ordinates, (Piaget, 1952; Piaget, et al, 1960).

Their theoretical and experimental work on geometrical concepts has probably made the greatest contribution to our knowledge of how the child gradually comes to take account of the invariance of such Euclidean concepts as length, area, and internal volume (Piaget, Inhelder and Szeminska, 1960).

Through the gradual mastery of these Euclidean concepts, the child eventually forms a coherent system of representation of one-, two-, and three-dimensional space in which he lives and moves. It is through actions that are performed on objects and figures, that the child is able to construct and transform spatial figures and thereby conceive a coherent system of geometrical relationships. As such, geometrical thought is seen as arising from the interiorization of actions performed. Imagery only supports spatial reasoning but is not itself sufficient, as Flavell (1963) implies in the following statement:

> "Our adult representation of space is thus said to result from actions performed on the spatial environment, rather than from the immediate "reading off" of this environment by perceptual apparatus" (Flavell, 1963, pp 328).

The vital element for bringing about coherent systems of geometrical thought are the operations or internalized, reversible actions. The child eventually needs to establish a picture of space as a kind of all enveloping container made up of a network of sites or subspaces. Within the container are objects, the things contained that move from site to site. Measurements of various kinds can be made within the container, without regard from whether the sites along which the measurements are taken are occupied or not. The child has to conceive of space as a medium which is homogeneous from the point of view of measurement, in spite of its heterogeneity as regards filled versus empty subspaces or sites. This is only part of what Piaget believes the child has to acquire vis-a-vis the Euclidean world (Piaget, Inhelder and Szeminska, 1960; Flavell, 1963; Holloway, 1967; Flavell, 1970).

Piaget, Inhelder and Szeminska (1960) distinguish three levels of achievement in the construction of Euclidean space.

(a) The first at substage 3a which is represented by the qualitative operations in the conservation of distance, length, area, and internal volume, and the conservation of congruences in the process of transfer from one position to another.

(b) The second level, at substage 3b, involves the achievement of simple operations, like measurement of length in one, two, or three dimensions, the construction of metric co-ordinate systems, and a first beginning of measurement of angles and areas.

(c) The final level is reached at stage 4 when areas and volumes are calculated. Only then is multiplication and simple measurement, as well as conservation of volume relative to the surrounding spatial medium achieved (Holloway, 1967).

Since the present study is concerned with the conservation of length, area, and internal volume, the review of related literature will focus on the studies related to the attainment of these three geometrical concepts.

According to Piaget (Lovell, 1966), the mastery of the conservations already cited depends on the elaboration and the coordination of Euclidean notions of change of position and subdivision. Space is said to be Euclidean when topological space is structured by reference elements since the use of such elements brings about the distinction between the two kinds of spatial reality, that is, "fixed sites" or "container" and "contained" or movable objects. Achievement of conservation implies the recognition that the "container" and "contained" remain invariant in spite of any changes in the positions of objects or parts of objects, or in certain other transformation in the "container" and "contained".

Piaget asserts that the evolution of conservation is a process of equilibration of cognitive actions which contains three major levels, namely:

(a) The level of no conservation: At first, the subject can only attend to one dimension of an object and his application is limited to the present. Later he can focus on two dimensions but both cannot be attended to at the same time.

(b) The transitional level: it is an empirically founded "on and off" sort of conservation; that is, the child hypothesizes conservation for some transformations and not others. For example, the child recognises that two congruent wholes remain equal when one or two congruent parts are subtracted from them, but not when twelve parts are involved.

(c) The level of conservation is characterized by a logically certain almost axiomatic assertion of conservation in the case of all transformation.

Piaget contends that all the major coming-into-equilibrium events in the development follow the same basic levels (Flavell, 1963). This stage - dependent development of conservation will be illustrated by citing some of Piaget's experiments, and some studies by other investigators concerning the conservation of length, area, and internal volume.

Studies on the concept of length

Piaget, et al, (1960) performed several experiments whose objective was to find out the age at which the subjects achieved the conservation of length when one of the identical objects was distorted in one way or the other, but its length had not been interfered with.

In one of the experiments, the subject was shown two straight sticks, identical in length, parallel to each other and their ends coinciding. One of the sticks was moved forward 1 or 2 cm. (the stick being approximately 5 cm. long), and the subject was asked to judge which of the two was longer, or whether they were the same length. At all levels, the sticks were judged equal before staggering.

After the change of position, subjects at the first stage maintained that the stick which had been moved was longer, thinking only in terms of further extremities. This response lasted into substage 2a. Between levels 2a and 2b the subject gave a series of transitional responses beginning with perceptual regulations and passing from inituitive regulations to operations when conservation of length was attained in stage 3a (Piaget, et al, 1960, pp 95).

In stage 3a, that is, approximately between the age of seven and eight years, the subject was convinced that length remains invariant because he could now equate the interval occupied by the rear part of the stick which had been advanced, with the interval occupied by its forward position. Conservation of length could not be assured in the absence of homogeneity between space as "container" and solid movable objects as "contained". This conservation though, does not imply the development of comprehensive systems of co-ordinates, which do not appear until the construction of metric schemata in substage 3b, because only by measuring distances can a subject compare distances irrespective of their location, and their orientation, as against comparisons between the length of an object and the empty distance in its immediate prolongation.

In a similar experiment, Piaget, et al, (1960) tested whether 59 children, aged between 4 and 9 years, recognised that the length of two identical rows remained equal regardless the distortion in shape of one of them. The subject was presented with two strips of paper each 30 cm. long and about

1 cm. wide. He was first asked to assure himself that the two strips were identical in length. One of the strips was then cut first into two parts and later into several and then arranged in a variety of ways, the aim being to establish whether there is conservation of the overall length.

It was found that at stage 1 and substage 2a conservation was lost when the strip was modified. Intermediate responses were given at substage 2b and at stage 3 conservation was understood. At the first stage there was no conservation in either situation. Some children at substage 2a showed the beginning of conservation when considering the matches, as they were influenced by the number of matches remaining the same, unless the change of arrangement was very great or one of the matches was broken. This failure was due to the lack of ability to consider together both subdivision and order or change of position. Stage 3 ($7\frac{1}{2}$ - $8\frac{1}{2}$ years) responses showed an ability to co-ordinate operations of subdivision and order or change of position, for example, "they're still the same size, only now they turn round " (Piaget, et al, 1960, pp 105 - 106).

Several of Piaget's studies on conservation of length have been replicated by a number of investigators. For example, in one study Lovell, Healey and Rowland (1962) tested 70 primary school children on conservation of length. Ten of the subjects were selected from 5 - year-old group, and 15 were from each of the 6,7,8, and 9 age groups. The authors also selected 10 pupils in each of the 9, 10, 11, 14, and 15 age groups among Educationally Subnormal (ESN) special schools children.

Two experiments for conservation of length were used: length of lines and coincidence of extremities (Piaget, et al, 1960, pp 91 - 95) and comparison of length and change of position (pp 95 - 102). In the first experiment the subject was supposed to compare the lengths of a straight wooded rod of 5 cm. long and a longer undulating thread of plasticine shaped like a snake. In the second task the subjects were expected to compare the lengths of two equal rods when the position of one was changed.

The results supported Piaget's theory of intellectual development. The protocols could be classified into the stages enumerated by the Genevan school provided a few intermediate stages were occasionally introduced. Again the numbers of children at various stages were not always what one might have expected from the results obtained from the Genevan children. It was also found that 14 - 15 - year - old ESN children had the operational mobility of normal 7½ year - old children. Lovell, et al, thus concluded that few of the least able school educable children reach Piaget's stage of concrete operational thinking.

In another study (Vernon, 1965), 50 eleven-year-old West Indian boys were compared with 100 boys of comparable age from South-east England. West Indian boys did not perform as well as English boys on conservation of length and area, among other tasks. Vernon attributed this lag to the lack of adequate experience, including lack of constructive play and failure to develop verbal concepts.

Similar results were obtained in a replication of the same battery of tests among 11 to 12-year - old Ugandan boys resident in Kampala (Vernon, 1969).

Beard (1968) also obtained similar results in a study in which she compared Ghanaian and English children. Ghanaian children were more handicapped than English children on conservation task. Like Vernon (1965, 1969), she concluded that failure to grasp concepts is largely due to lack of experience.

Though the conclusions of Vernon (1969) and Beard (1968) can be held in question since they used English language when testing african children for whom English was not the mother tongue, some developmental lag has been reported even when vernacular was used in the testing situation (Okonji, 1970).

In Okonji's (1970) study, 358 Banyankole children were tested by a research assistant who was a native speaker of the language spoken by the children. One group of subjects, aged between 6 and 11 years, were all going to school. The other group in the study was composed of children who were non-school going and had never attended any school. Their ages ranged from 6 to 16 years.

Schooling children performed significantly better than the non-schooling children from the age of eight. Most of the non-schooling children seem to have reached a developmental plateau by age six as far as conservation of length is concerned. A similar finding by age eight had been reported by Greenfield (1966) who investigated the performance of unschooled, rural Wolof children on a conservation of liquid task.

The schooling children's superiority in this task on conservation of length seemed to increase with the number of years at school. But, on the whole, even the performance of schooling children was poor by Piagetian standards. For example, of the fifty one, 6 - 7 - year - old schooling children only seven were conservers, and out of thirty four 8 - 9 - year old sixteen were conservers.

The finding that schooling African children perform better on conservation of length tasks than their unschooled counterparts has also been supported by the results of a similar study by Page (1973). He used as his subjects 133 Zulu youths aged between 11 and 20 years, selected from rural and urban areas.

A comparison of schooled and unschooled subjects matched for age and urban-rural residence indicated a strong relationship between Piaget's stage 3 - performance (conservation) and schooling. For rural youths, simply getting older did not guarantee the acquisition of more sophisticated concepts of space

Studies on the concept of area

In the study of two-dimensional space Piaget, et al, (1960, pp 394) have again illustrated that coordination of the processes of subdivision and change of position facilitate the acquisition of conservation of area.

In one of the experiments the subject was confronted with two cardboard figures. After asserting that they were the same size, (same amount of room in each), a piece was removed from one of them and moved to another part of the figure and the subject was asked to say once again if one of the figures was larger, or if they were the same size.

In a similar experiment, children were faced with two identical rectangular sheets of green cardboard which were described as meadows with grass for cows to eat. They were enabled to realize the identity of the fields by putting them side by side to make sure. A model cow and farmer were introduced and the children had no difficulty in appreciating that each cow had the same amount of grass to eat. They were then told that one farmer decided to build a house on his meadow - a model about 1 cm. by 2 cm. or a cube or wooden brick to stand for the farmhouse being placed on one meadow.

All the children questioned were able to say at once that the cow in the field with the house had less grass to eat than in the field without the house. When an identical house was placed centrally in the field and the other near one corner, and the procedure was continued by adding further identical houses to each field, those in one field being distributed at random with "grass" space between them and those in the second field being placed adjacent to one another in a continuous line, younger children were deceived by the arrangement, not seeing that two houses closed up into the corner occupied the same space as two identical houses widely spread from one another. Some children maintained the sameness of the grass area for a small number of houses and lost it for a large number, while older children maintained it throughout.

The results of these experiments, and of several others show a developmental trend from non-conservation, to necessary and operational conservation. Piaget and his colleagues proposed the following developmental plan:- (Piaget, et al, 1960; Lovell, 1966).

Level 1 (less than 5 years of age).

It was difficult to pursue the experiment.

Level 11a (5½ - 6 years).

Children confined themselves to perceptual judgements and areas were not conserved when their appearance was modified.

Level 11b (6 - 7 years).

Children gradually came to make a number of true judgements but their success was the product of intuitive adjustments and so lacked generality.

Level 111a (from $7\frac{1}{2}$ years, but sometimes as early as $6\frac{1}{2}$ to 7 years).

There was operational conservation of area when shape was altered or when smaller congruent parts were subtracted from larger congruent areas. But conservation was limited to an area enclosed by a given perimeter and did not extend to complementary area outside. The concept of unit was not understood as such, and children counted all the parts of an area regardless of their size.

Level IIIb

Now conservation was generalized to cover complementary areas and this level marks the beginning of measurement involving unit iteration.

It was shown, therefore, that younger children succumbed to perceptual illusions and, thus, could not conserve area. But older children took note of the illusory impression and confidently discounted it by reasoning. These children have learnt the principle of reciprocal compensation whereby the spaces left free and those which are newly occupied mutually compensate one another.

Work by Lovell, Healey and Rowland (1962) has supported the general developmental sequence as illustrated by Piaget's experiment involving toy "cows eating grass" in two fields in which "houses" were built. Lovell, et al, (1962) replicated the experiment using 70 primary school children whose ages ranged from six to nine and 10 pupils each from the 9, 10, 11, 14 and 15 age groups among (ESN) special schools children. The authors report that most of the children admitted that there was the same amount of grass in each field. But most children either denied conservation of area, as soon as two houses were built in each field, or else went right through to the end admitting conservation (16 houses). They found, for example, few children, who admitted up to 4, 5, 6 houses and then denied conservation because of greater perceptual difference. These results led the authors to conclude that chronological age was not a very good indicator of performance, because some children at 5 or 6 years of age conserved area right to the end of the experiment while older children could not.

An interesting cross-cultural study in which conservation of area was studied was reported by Goodnow (1962). She found that, contrary to what she had anticipated, the conservation of area and volume tasks were too difficult for her Hong Kong subjects.

Children involved in this investigation were 10,11,12, and 13 years of age. They were drawn from different socio-economic grounds. She studied Europeans, Chinese from high ranking Anglo-Chinese schools, and Chinese boys of low socio-economic status.

On the conservation tasks, milieu, schooling, and socio-economic status had far less effects than had been anticipated, although the groups were far apart on the Raven's

Progressive Matrices Test. Unschooled Chinese did as well as European and American school children on tasks on conservation of surface (area), weight, and volume. In contrast, they were markedly poorer on another Piaget task, that of combinatorial reasoning, as well as on the Raven's Progressive Matrices test. Goodnow (1962) suggested that the latter was unreliable for unschooled children, probably because it is more culture-bound than the others.

The discrepancy between conservation and combinatorial tasks raised the question as to whether the conservation tasks were insensitive to the lack of schooling or whether they were insensitive to differences in intelligence.

A study by Goodnow and Bethon (1966) attempted to answer this question. The subjects for the study consisted of 192 eight and eleven - year - olds. These subjects were categorized as follows:

In the 11-year - old group, there were 32 superior, 64 average and 32 dull subjects. In the 8 - year - old group, there were 32 average and 32 superior subjects.

The results of this study indicated increasing proportion of success with increasing mental age, on all the tasks. For example, among the 8 - year - olds the superior group having a mental age of 11.3 did significantly better than the average group having a mental age of 8.8. It did not appear that a young child with a high mental age was held back by lack of experience which chronological age provides. For example, the superior 8 - year - olds performed as well as the average 11 - year - olds. They were comparable in terms of mental age. The results led the authors to conclude that variations in intelligence are to be seriously considered in any comparison of children by way of Piaget's tasks.

The conservation tasks, as in the earlier study (Goodnow, 1962), emerged as insensitive to schooling. The authors suggested that conservation could be upset by particular kind of schooling, for example Goodnow (1962) had found that a poor science course and an attitude of down-playing the evidence of ones own experience created difficulties for one group of Chinese subjects. But in the normal course of events, children acquired the skills they needed for these conservation tasks without the benefit of schooling.

However, the combinatorial task was sensitive to schooling and it was suggested that this was so because the task demands working things "out in the head" by thought rather than by eye and hand. But the conservation tasks have more direct counterparts in the experience of the child. In the experimental situation the child can refer to the fact he divided parts of clay or moved parts of an area, to check that they are equal. Outside of it he can draw on the past experience with changes in shape.

Working on the hypothesis that in nonwestern societies, intellectual development follows a different path from that followed in western societies, depending on the cultural ideals, child-rearing practices and educational systems, Vernon (1965, 1969) carried out some investigations among 10 to 12 year - old boys in the West Indies and Uganda. He administered a battery of several tests, some of which were tests of conservation including area and length.

In the first investigation (Vernon, 1965) 50 West Indian boys were tested and their results were compared to those of a comparable group of 100 boys from South East England. When all the scores on conservation tasks were combined, the median West Indian performance fell at 86 on English norms, indicating a moderate degree of retardation. But the results clearly varied much on the different items. The greatest deficiencies occurred in number concepts, conservation of water, conservation of rod lengths, conservation of area, and visualising insect. The differences were quite negligible on logical inclusion and conservation of plasticine.

Similar developmental lag was found among the 50 12 - year - old Ugandan boys from Kampala. The selected pupils were supposed to be fluent in English and the test was administered in English by an African student. The results indicated again that the worst deficiencies were in conservation task where over 50% of the subjects were nonconservers in every item.

Vernon (1969) concluded that though his results show a considerable variation on different kinds of Piaget tasks, it seemed plausible that magical beliefs might especially affect the attainment of conservation. On the other hand, poor performance could have resulted from a difficult in communication of ideas because Bruner and his colleagues (1966) and Otaala (1970) obtained fairly good results with schooled children in Senegal and Uganda respectively, who were given conservation tasks in vernacular. However, it is difficult to make definite conclusions on this issue on the basis of scarsity of data and from the fact that the results were not based on the same tests, administered and scored in a similar manner.

In a recent study, Lester and Klein (1973), found that the performance on the conservation of area (farm) that had been judged as familiar stimulus by a sample of the adult population from which the sample of children was drawn, improved with age irrespective of sex or repeated testing. But in the conservation of area (cubes) which had been judged as unfamiliar stimulus, performance did not improve across the five to seven - age range.

The authors concluded that high performance was associated with familiarity of the stimulus material and appropriateness of the task to the rural farming community. Repeated testing was associated with significant improvement for the conservation of area (farm) task. This led the authors to question the conclusions reached by cross-cultural researchers who used performance on tasks, across short intervals, for comparison between western children and others for whom, skills for optimal performance on psychological tests are not normal products of the socialization process.

Studies on the concept of Internal Volume

The conservation of "Internal" volume, that is, one that does not entail the calculation of volume together with the elaboration of metrical relations between volume under consideration and surfaces bounded by it, "may well be acquired at level 3a together with conservation of length and conservation of area", (Piaget, et al, 1960, pp 355). Such conservation is based on the conception of area and volume as that which is bounded by lines (or faces). It comes before the ability to calculate areas or volumes by mathematical multiplication involving relations between units of different powers.

In one of the experiments to test the conservation of internal volume, children were shown a solid block representing a house 4 cm. high, on a base measuring 2 cm. x 2 cm., 3 cm. x 4 cm., or 1 cm. x 3 cm. Children were told they had to build other houses with "as much room" as the block, on the other cardboard bases. They had to keep the volume constant while altering the base on which the house was built, and instructions had often to be given to the effect that the house must be kept on the cardboard and must not extend beyond it.

Moreover, the new "house" had to be made out of 1 cm. x 1 cm. x 1 cm. cubes.

The following developmental scheme was proposed:-

Stage I - (below the age of 4 or five)

These techniques were impracticable.

Stage IIa - (from 4½ years)

Any transformations and reconstructions or comparisons of volume were made entirely in terms of one dimension only, usually the largest. Irrespective of the size of the base, the subject always stopped when he reached the height of the model. When attempting to reproduce a given volume, children tended to follow boundary surfaces. When asked to make comparisons between volumes, they did so without using a common measure, as in one-dimensional terms.

Stage IIb

Attempts were made to reproduce an equivalent volume on a different base. Sometimes children made their building higher than the model. This means they were beginning to use logical multiplication in their handling of relations between two dimensions

Stage IIIa (beginning at the age of 6½ to 7½ years)

Children began to work out relations between the three dimensions, using only logical multiplication, that is, without measuring or making more exact compensations based on a unit system. Conservation exists now, but only in regard to interior volume for the subject recognised the invariance of the amount of matter which is contained within the boundary surfaces.

Stage IIb (beginning around the age of 8 or 9 years)

Children began to measure correctly, using the unit cubes as units, but they still did not carry out mathematical multiplication which means they could not establish numerical relations between lengths and areas and volumes. Theirs was a compromise between logical multiplication of relations involved and attempts at using mathematical calculation by treating volume as if it was the outcome of addition of areas. Discovery of the mathematical relation between area and volume, that is, two volumes are equal if the products of their respective elements are equal, was attained in stage IV at about 11 to 12 years.

Lunzer (1960) made a follow-up study of the concept of internal volume. His investigation involved replication of the experiment in which unit cubes were used for constructing "houses" of different bases but of equal volume.

Although his sample was small (N - 24), the data clearly supported Piaget's hypothesis that conservation of "internal" volume of the cubes is attained earlier than both the conservation of "occupied" volume and width x length x height measurement of volume. These latter two are formal rather than concrete operational.

A study of the development of physical volume has also been studied by Lowell and Olgivie (1961). Notions of internal volume, volume as occupied space, complementary or displacement volume were studied in a group of 191 junior school children. The sample was drawn from the first four grades of the junior school. The results revealed that some two-thirds of the first and second year pupils, and over 90 per cent. of the third and fourth year pupils, conserved internal volume of a block made up of twelve cubes. "Occupied" volume was conserved by 40 per cent of the first year pupils, and over 80 per cent of the fourth year pupils. Displacement volume often seemed to be regarded as dependent upon the weight of the object immersed, the size of the container and other factors. These irrelevant influences were only slowly eliminated with age. Only 75 per cent. of the fourth year pupils, for example, maintained that the amounts of water displaced were the same when a 2 x 3 x 2 block was replaced by a 1 x 2 x 6 block. If the test about the amount of water displaced in relation to the depth of a cube in water is ignored, it was found that only 3 children in the first, year, 5 in the second, 5 in the third, and 21 in the fourth year were successful in all the tests.

Lovell and Olgivie (1961) concluded that an understanding of physical volume in any generalized sense does not develop until late in the life of the junior school child,and, even then, there were many gaps in his knowledge. Children have to learn to eliminate the irrelevant factors and this is a slow business, as the junior school child finds it difficult if not impossible, to consider the effect of one variable while holding the other variables constant.

The results obtained by Lovell and Olgivie (1961), have been supported by the results of Andrejczak's (1972) investigation. He found that interior volume is attained before either occupied or displacement volume. His subjects comprised 120 children from an upper middle-class environment. Thirty subjects (15 boys and 15 girls), were selected from the fourth, sixth, eighth and tenth grades. All subjects were matched for intellectual ability by having verbal and nonverbal standard scores on the Longe-Thorndike Scale between 100 and 120.

Studies on the concurrent acquisition of the concepts of length area and internal volume.

According to Piaget, Inhelder and Szeminska (1960, pp 394) the processes of subdivision and change of position and their evolution from topological to Euclidean characteristics, are responsible for the acquisition of conservation of length, area and internal volume. In all these Euclidean entities, the achievement of conservation is dependent on the recognition of fixed or relatively fixed spatial "container" and a movable "contained". It is this recognition which enables the child to co-ordinate subdivision and change of position and hence to recognise the conservation of length, area and internal volume when objects are subjected to modification of shape.

The above hypothesis was tested by Beilin and Franklin (1962). Their sample consisted of 27 first grade children whose mean age was 6½ years and ranging from 6 years to 7 years 3 months; and 33 third grade children whose mean age was 8 years 11 months, ranging between 8 years 1 month and 9 years 4 months. This sample was drawn from a lower middle-class American community.

Beilin and Franklin (1962) found that conservation and measurement of length, were easier than those of area. The authors concluded that conservation and measurement of length, area and internal volume were acquired in that order, their acquisition being a function of the complexity of the concept. Complexity depends on the increase in the number of sides that have to be considered in each concept simultaneously.

The results of a study by Goldschmidt (1967) seemed to suggest that area, length and internal volume were mastered in that order. Goldschmidt's sample consisted of 102 first and 2nd grade children drawn from three urban schools. Some of the subjects were from upper middle-class families but 21 of the children attending a clinically oriented day school, came from lower middle-class families. The mean age of the younger group of children was 6.7 years and that of the older group was 7.7 years.

In another study, Omari (1973) suggested that distance, which is an equivalent acquisition to length, is an earlier acquisition than conservation of area. His sample consisted of 240 Tanzanian school children, 60 from each of grades 1, 3, 5, 7. On the basis of the results, Omari concluded that the acquisition of these concepts is a function of the spatial dimensions in each concept. Thus, his conclusions tend to support the suggestion put forward by Beilin and Franklin (1962).

Sex differences

Although Piaget did not indicate whether sex had any influence on the performance on conservation of Euclidean concepts, some studies based on his theory have investigated this. For example, Goldschmidt (1967) reported that a group of 6 - to 7 - year - old boys performed better than girls of the same age on a number of conservation tasks, among which were length, area, and internal volume. Goldschmidt postulated that boys, more than girls, had in their play activities, more opportunities to manipulate objects and perceive them under different transformations.

Fogelman (1970) reported a study in which 6 - to 7 - year - old English children were tested for conservation of substance, using both passive and active methods. Under passive conditions, the experimenter manipulated the materials as the subjects watched and listened. Under active conditions, children manipulated the materials themselves. The results indicated that, on the whole, girls performed better than boys. They were superior under passive conditions while boys did better under active conditions. Fogelman suggested that boys did better when they could manipulate objects about which they must think probably because they were encouraged in interests that were mechanical. Girls, on the other hand, preferred the passive situation where they could pick up verbal cues, which were available to the verbal group as their interests were more likely to be literary or aesthetic.

However, some studies have reported that there were not significant sex differences in performance on conservation tasks. For example, Lester and Klein (1973), did not find any significant sex differences in performance on conservation of area tasks. Their subjects included 5 - and 7 - year - old Guatemalan children. Their results supported those of a number of previous studies based on the other conservation tasks (Case and Collison, 1962; Greenfield, 1966; Pratoomraj and Johnson, 1966).

Therefore it would appear that sex differences in performance on conservation tasks depends on cultural props. If the culture encourages boys to perform different daily tasks from girls, and encourages them to have different interests, expectations, role and occupational prospects, these, in turn, might affect performance on conservation tasks.

Summary of the Review of Related Literature.

On the basis of the investigations conducted to date, it would appear that performance on the concepts of length, area, and internal volume improves with age. According to Piaget and his associates, the three concepts are mastered simultaneously since their acquisition depends on the same operations of division and change of position.

The results of several of the studies that have been reviewed also tend to suggest that physical, social and cultural factors affect the age at which conservation is attained. In some sultures, mastery of these concepts may be earlier and in some, later than postulated by Piaget. This points to the fact that norms obtained from one cultural group may not always be applied validly to another group that is relatively different. Besides chronological age, a number of other factors have been shown to influence performance on conservation tasks. They include intelligence, sex, schooling, rural versus urban environment, language, and familiarity with the tasks.

Results of some of the studies that have investigated the influence of sex on performance on conservation have not been very consistent. It seems that sex differences in performance of these tasks depends on cultural props.

The review of literature also seems to suggest that a child may be in several levels of development simultaneously. He can acquire the concept of area, for example, before those of length and volume. Acquisition of these concepts, may depend heavily on familiarity of the tasks, previous experience, motivation or role expectation. Thus, again, culture has a part to play in the attainment of these concepts. The order of acquisition could vary according to different cultures.

In view of the differences and inconsistencies reported above, the present study was designed to investigate whether older children would perform better than younger children, whether length, area and internal volume conservation is concurrent and whether boys would perform better than girls on these conservation tasks. The study was based on rural Kikuyu primary school children.

CHAPTER THREE

METHOD

SUBJECTS

Thirty pupils, fifteen boys and fifteen girls were selected from each of the alternate primary school classes (standards 1, 3, 5, 7,) making a total of one hundred and twenty subjects. The first 15 boys and the first 15 girls on the register were selected from each class to participate in the present investigation.

Table I shows the mean age and the age range of the boys, while Table II shows a similar distribution for the girls.

Table I: The mean age and the age ranges of the boys by Standard.

STANDARD	N	MEAN AGE	AGE RANGE
1	15	7 yr. 6 mon.	7 yr. - 10 yr.
3	15	9 yr. 1 mon.	9 yr.- 10 yr.
5	15	12 yr. 6 mon.	11 yr. - 14 yr. 3 mon.
7	15	14 yr. 0 mon.	12 yr. - 15 yr. 6 mon.

Table II: The mean age and the age Ranges of the girls by standard.

STANDARD	N	MEAN AGE	AGE RANGE
1	15	7 yr. 9 mon.	6 yr. 3 mon - 10 yr. 7m.
3	15	9 yr. 3 mon.	8 yr. - 11 yr.
5	15	12 yr. 1 mon.	10 yr. - 14 yr. 6 mon.
7	15	13 yr. 6 mon.	12 yr. - 14 yr. 0 mon.

The subjects were all day scholars attending Karunga Primary school which is situated in a densely populated area about three kilometres from Kiambu town. The area lies approximately 20 kilometres to the northwest of Nairobi.

Children who constituted this sample come from a peasant farming community. Each of the families own a small "Shamba" from which they obtain most of their subsistence crops.

Women and children carry out the farmwork as men are usually employed either as labourers in nearby coffee plantations or in unskilled or semiskilled jobs in the urban areas. About 20% of the fathers of the children who were interviewed had no other source of income besides their own shambas, while another 17 per cent engaged in some form of business.

The primary school children make essential contributions to the running of the household. From an early age, they become proficient in a variety of household and farm tasks, such as baby tending, cooking, fetching water, cultivating and cattle herding. Before the age of 10 years, there does not seem to be clear division of labour between girls and boys. But from the early teens, boys tend to engage more in such tasks as farmwork, and cattle herding, while girls do housework and fetch water. The older children have heavy responsibilities in the evenings, despite the fact that they are expected to prepare themselves for the certificate of Primary Education Examination (CPE) which is taken at the end of seven years of Primary Education.

Despite these responsibilities, most children have some time to engage in leisure activities. Boys usually play games and sports learnt at school, such as football, volleyball, running and jumping. Generally, they make their own playing equipment out of local materials, for example, banana fibre, sisal and sticks.

Skipping, hide and seek, and 'playing mothers' are the more popular leisure activities among the girls. It was observed that most of the older girls do not usually play unlike their male counterparts, probably because they are given heavier responsibilities or because their parents restrict their freedom to wonder away from adults.

Few of the children grow isolated from their peers because related families live close to one another and children from one family can go to the next home and play with the neighbours. Again individual families are fairly large, having on the average 6 to 7 children. However, large families are associated with overcrowding since the houses have, on the average, two to four rooms and quite often two or three children have to share a bed.

These are some of the out of school experiences and expectations that these children bring with them to school, and which might affect their performance on cognitive tasks.

STIMULUS MATERIALS

Conservation of length

Task One.

This task was designed to test whether the subject saw length as invariant regardless the change in position in one of the two sticks of identical length.

The materials for this task consisted of 6 sticks. Four of them were equal, each being 10 cm long. One was shorter, being 9 cm long, and one was longer being 11½ cm long. All the sticks were equal in diameter, being 5 mm. A cardboard (25.8 cm x 22 cm), with marked positions for placing the sticks was also used.

Task Two

The second task was designed to test whether the subject saw length as invariant irrespective of distortion in shape of one of the chains.

Four pieces of chain attached to a safety pin at one end were used. Each was about 2 mm wide. Two of them were equal, each being 14.5 cm. One of them was shorter, being 13.5 cm. long and the other was longer, being 15.5 cm long.

Conservation of area

Task One

In this task, the subject was tested to see if he recognised area as invariant regardless the change in shape in one of the two congruent rectangles.

One cardboard rectangle, 9 cm x 7 cm and two triangles formed by cutting diagonally, rectangle congruent to the above, were used as the stimulus material for this task.

Task Two

The subject was tested to see whether he recognised that two congruent wholes remain equal when congruent parts are subtracted from them.

Two cardboards, 25.8 cm x 22 cm, each representing a grazing field, two toy goats, each about 5 cm long, and twenty four matchboxes were used.

Conservation of Internal volume

Task One.

This task was designed to test whether the subject realized that two "Houses" having equal internal volume remain equal when the shape of one is altered.

The materials for this task included two cardboards 25.8 cm x 22 cm and twenty four matchboxes.

Task Two

The aim of this task was to find out whether the subject appreciated that two "houses" of different shape can have the same internal volume.

The materials for this task included the two cardboards used in the previous experiement and forty matchboxes.

PROCEDURE

The headmaster introduced the investigator to each of the classes from which the subjects, who participated in the study were selected. The investigator, then explained to each subject before the individual interview that she was interested in finding out how children answer certain questions and the reasons they give for their answers. The different tasks were administered as follows.

Conservation of length.

Task One.

The experimenter placed the cardboard on the table in front of the subject. The sticks were handed to the subject and he was asked to select the longest, the shortest, and two which were equal in length. (This step served to ensure that the subject was familiar with such keywords as "Longest", shortest" and "equal", and to familiarize himself with the testing situation. After making the selection, the subject was asked to hand the sticks to the experimenter.

The sticks were placed on the cardboard with their extremities coinciding. The subject was asked to judge whether the sticks were still of the same length. The following procedures then took place:

(a) the stick which was nearer the subject was placed in such a way that it intersected with the other at right angles about 8 cm from one end.

(b) the sticks were placed at an acute angle, of about 30°. On each occasion, the subjects were asked if the two sticks were still the same length. Each time they had to justify their answer.

Task Two

The subject was asked to select the longest, and the shortest so that he was left with two which were of equal length. The subject was then questioned to see if he recognised that the two chains placed parallel to each other with their end points at the same point were equal in length.

While the child watched, the chain which was nearer to him was bent. Again he was requested to judge whether the chains were still equal in length

Conservation of Area

Task One.

The subject was requested to superimpose the two congruent rectangles, one made up of the two triangles, to convince himself that they were equal. Then the two rectangles were placed on the table, in front of the subject. He was asked to confirm whether the two rectangles were of the same size.

One of the rectangles was transformed into a triangle and the subject had to compare the rectangle and the triangle and confirm whether they were still of the same size. On each occasion, a response justification was demanded.

Task Two

Two congruent cardboards were handed to the subject and he was asked to superimpose them to convince himself that they were of the same size. The experimenter helped the subject to superimpose the boards if the latter found it difficult.

The cardboards were placed side by side, and the subject was told that they represented grazing fields. He was requested to judge whether there were equal amounts of grass-covered spaces in the two field.

A toy-goat was placed in each of the fields and the subject was asked whether each goat was provided with the same amount of grass-covered space as the other.

The subject watched as the experimenter added matchboxes (houses) to the fields, placing one on each field at the same time until each field contained 12 matchboxes. In one field, the matchboxes were scattered; in the other, they were in a row near one edge of the field. The subject was asked if each goat had as much grass-covered spaced as the other or if one had more. A response justification was demanded when there was one, two and twelve matchboxes in each field.

Conservation of internal volume

Task One.

The investigator explained that she wanted to build one house for the subject and one for herself. The two houses were built in the form of 2 x 2 x 3 matchboxes. (The first figure is for length, the second for breadth, and the last for height). The subject was requested to judge whether the two houses were equal. If the response was that they were equal, the subject was asked to indicate which one could hold more things (This was to ascertain that he was considering volume and not appearance, since during the pilot study it had been found difficult to convey the exact meaning of volume in vernacular).

One of the houses was then reconstructed into two other shapes, first, 6 x 2 x 1 matchboxes, and then into 12 x 1 x 1 matchboxes. After each transformation the above questions were repeated.

Task Two.

One house was built on one of the cardboards, in the form, 2 x 2 x 2 matchboxes, Four other houses were built in the other cardboard in the following manner:- 2 x 2 x 2; 4 x 2 x 1; 2 x 2 x 2 minus one matchbox on the top layer, making a total of seven matchboxes; 2 x 2 x 2 plus one matchbox on top, making a total of nine matchboxes.

The subject was requested to select the houses from these four which were equal to the one on the other cardboard and to justify his choice.

The detailed interview schedule is available in appendix 1.

The conservation of area tasks were presented first, followed by length, and internal volume. This order of presentation was stimulated by the desire to separate the tasks of internal volume and area since the materials used for both were similar.

All the tasks were administered by the investigator herself in the Kikuyu language. The subjects were tested individually in the staffroom.

Although the subject was allowed to handle the materials and to superimpose them at the beginning of each task, all the other transformations were carried out by the experimenter herself, while the subject watched.

The stimulus material was kept out of sight, till the particular test started since it was evident during the pilot study that the attention of some subjects was distracted if the materials were exposed.

A maximum of 60 seconds was allowed for each response including justifications. The experimenter did not include the time spent on questioning, transformations and recording.

The interviews were carried out between the last week of September and the third week of October, 1973.

SCORING

The investigator aimed at both distinguishing conservers from non-conservers, and to compare different groups on the basis of actual performance on the tasks. To classify a subject as a conserver or non -conserver the pattern formed by the answers and justification for different responses in each task was examined.

Conservation of Length.

In the conservation of length, the subject was considered a conserver if length was considered constant in both tasks and justifications revealed operational level of thinking.

Task one offered three opportunities for conservation and task two one opportunity. For a subject to be considered a conserver, he had to obtain three out of four responses right plus correct justifications.

Conservation of Area.

For conservation of area, the subject was classified a conserver if he recognised area as invariant regardless of the arrangement of parts of the rectangle in one task or the arrangement of the houses in the other.

In one task there were 2 opportunities and in the other 3 opportunities for displaying conservation.

The subject was considered passed if he obtained 4 out of 5 responses right with correct justifications.

Conservation of Internal volume

The subject was regarded operational if he recognised the invariance of the size of the houses regardless of the transformation in shape in one of them.

In task one, there were two responses. In task two, there were two correct alternatives. The subject had to recognise the two correct alternatives to be considered passed in this particular task. Thus, for internal volume, the subject had to pass 2 out of 3 responses right and give correct justifications to be considered a conserver.

In order to compare the different groups on the actual performance each correct response, plus correct justification was awarded one point. If the subject gave an incorrect response, or if the response was correct but the justification was incorrect, or he gave a don't know response, he was awarded a zero mark. The points for the different responses were added up to give an individual a mark for each concept. The marks for length tasks ranged from 0 to 4, for area from 0 to 5, and for internal volume from 0 to 3 points. Therefore, for the purposes of analysis, each subject had three marks: for length, area, and internal volume.

CHAPTER FOUR

RESULTS

Age Differences

The obtained data were statistically analysed to find out whether older children would perform better than younger children on conservation of length, area, and internal volume.

A comparison was made between the number of conservers and non-conservers using a chi-square analysis. The results of the chi-square analysis for length conservation are shown in table III and IV.

Table III: The number of boys who conserved and those who did not conserve length by standard.

	GRADE LEVELS			
	SI	SIII	SV	SVII
CONSERVERS	4	8	11	13
NONCONSERVERS	11	7	4	2

$X^2 = 12.78$; df = 3, 1; critical value = 11.3; $p = .01$.

Table III shows that the number of boys who conserved length significantly rose from standard one through standard seven ($X^2 = 12.78$; df = 3, 1; $p < .01$).

A similar analysis for girls is shown in table IV.

Table IV: The number of girls who conserved and those who did not conserve length by standard.

	GRADE LEVELS			
	SI	SIII	SV	SVII
CONSERVERS	4	3	9	12
NONCONSERVERS	11	12	6	3

X^2 = 14.46; df = 3,1; critical value = 11. 3; p = 01.

S - stands for Standard

NB. 'Grade' and 'standard' are used interchangeably throughout the chapter.

Thus, for girls, the rise in the number of conservers from grade one through grade seven was also significant ($X^2 = 14.46$; df = 3, 1; $p < .01$). It should be noted, however, that while more than half of the boys attained conservation in standard three, more than half of the girls did so in standard V.

An F-test was also used to analyse the effect of grade (age) on conservation of length using actual scores. The mean scores on length conservation task are given in table V.

Table V: Mean scores on conservation of length Task by standard and Sex.

	GRADE LEVELS			
	SI	SIII	SV	SVII
BOYS	1.53	2.60	3.20	3.27
GIRLS	1.33	1.93	2.33	3.27

Maximum score = 4

The results of the F - test are shown in table VI.

Table VI: Analysis of variance summary Table for conservation of length.

SOURCE	SS	df	ms	F	P
Grade	54.90	3	18.30	13.2	.01
Sex	5.66	1	5.66	4.10	.05
Interaction	3.76	3	1.26	0.82	NS
Error	165.18	112	1.38		
Total	229.50	119			

NS = Not significant

The analysis of variance (table VI) revealed that older subjects (in upper grades) performed significantly better than younger subjects (in lower grades) ($F = 13.2$; $df=3/112$; $p < .01$). Table VI also shows that sex was a significant factor ($F = 4.1$; $df = 1/112$; $p < .05$) but interaction between grade and sex did not reach significance ($F = 0.82$; $df = 3/112$; $p > .05$)

Table VII shows the number of those boys who conserved and those who did not conserve area.

Table VII: The number of boys who conserved and those who did not conserve area.

	GRADE LEVELS			
	SI	SIII	SV	SVII
CONSERVERS	0	10	10	10
NONCONSERVERS	15	5	5	5

X^2 = 19.98; df = 3,1; critical value 11.3; p.01.

Among boys there was not conservation of length in standard one. But the chi-square analysis showed a significant rise from this state of non conservation to the number of boys who conserved area in standard three (X^2 = 19.98; df = 3,1; $p < 01$). From standard three to standard seven there was no increase in the number of conservers.

The number of girls who conserved and those who did not conserve is shown in table VIII.

Table VIII: The number of girls who conserved and those who did not conserve area.

	GRADE LEVELS			
	SI	SIII	SIV	SVII
CONSERVERS	2	1	5	8
NONCONSERVERS	13	14	10	7

$X^2 = 10.23$; df = 3,1; critical value = 11.3; $p. < .05$

Table VIII shows a significant rise in the number of girls who conserved area from standard one through standard seven ($X^2 = 10.23$; df = 3,1; $p < .05$). However, only half of the girls had mastered area conservation even in standard seven.

Table IX shows the mean scores for conservation of area tasks.

Table IX: Mean Scores on Conservation of Area Task by Standard and Sex.

	GRADE LEVELS			
	SI	SIII	SV	SVII
BOYS	1.73	3.53	3.73	3.6
GIRLS	1.27	1.93	2.93	3.27

Maximum score = 5

The analysis of variance summary table that was performed on the means given in table IX is given below (table X).

Table X: Analysis of variance summary table for conservation of Area.

SOURCE	SS	df	MS	F	P
Grade	71.09	3	23.696	14.3	.01
Sex	19.20	1.	19.20	11.3	.01
Interaction	7.51	3	2.50	1.48	NS
Error	186.79	112	1.70		
TOTAL	284.59	119			

Table X shows that older subjects (in higher grades) performed significantly better than younger subjects (in lower grades) on conservation of area tasks ($F = 14.3$; $df = 3/112$; $p < .01$). Sex was also a significant factor ($F = 11.3$; $df = 1/112$; $p < .01$), but interaction between grade and sex was not significant ($F = 1.48$; $df = 3/112$; $p > .05$).

The number of boys who conserved and those who did not conserve internal volume is shown in table XI.

Table XI: The number of boys who conserved and those who did not conserve internal volume

	GRADE LEVELS			
	SI	SIII	SV	SVII
CONSERVERS	5	4	9	10
NONCONSERVERS	10	11	6	5

$X^2 = 6.98$; df= 3,1; critical value 7.8; p. 05.

The chi-square value shows that for boys the rise in the number of conservers from standard one through standard seven was not significant ($X^2 = 6.98$; df = 3, 1; $p. > 05$).

Table XII shows the number of those girls who conserved and those who did not conserve internal volume.

Table XII: The number of girls who conserve and those who did not conserve internal volume.

	SI	SIII	SV	SVII
CONSERVERS	0	3	7	7
NONCONSERVERS	15	12	8	8

$X^2 = 11.41$; df = 3,1; critical value = 11.3, p .01.

The chi-square value shows a significant rise in the number of conservers from standard one to standard five ($X^2 = 11.41$; df = 3, 1, $p < .01$). From standard five to standard seven, the number of conservers remained constant.

The mean scores on conservation of internal volume tasks are shown in table XIII.

Table XIII. Mean scores on conservation of internal volume tasks by standard and sex.

	GRADE LEVELS			
	SI	SIII	SV	SVII
BOYS	0.73	1.07	2.0	2.07
GIRLS	0.20	0.87	1.2	1.47

Maximum Score = 3

The differences between the mean scores in table XIII were analysed using on F-test. The results are given in table XIV.

Table XIV: Analysis of variance summary table for conservation of Internal volume.

SOURCE	SS	df	ms	F	P
Grade	32.19	3	10.73	10.12	.01
Sex	8.54	1	8.54	8.04	.01
Interaction	1.42	3	0.47	0.44	NS
Error	119.05	112	1.06		
Total	161.20	119			

As table XIV indicates, older children (in higher classes) performed significantly better than younger children (in lower classes) on conservation of internal volume tasks ($F = 10.12$; $df = 3/112$; $p < .01$). Sex was also a significant factor ($F = 8.04$ $df = 3/112$; $p < .01$), but there was not significant interaction between grade and sex ($F = 0.44$, $df = 3/112$; $p > .05$).

Concurrent mastery of conservation of length, Conservation of Area, and Conservation of Internal Volume

It was expected that the mastery of conservations of length, conservation of area, and conservation of internal volume would emerge concurrently as postulated by Piaget, that is, these concepts emerge simultaneously since their mastery is dependent on the same spatial - temporal operations of subdivision and change of position.

Correlation coefficients were used to compare the performance of each class on two concepts at time. A high

Correlation would indicate simultaneous acquisition of the concepts.

TABLE XV: Correlation Coefficients for length and Area.

STANDARD	N	CORRELATION COEFFICIENT	SIGNIFICANCE
I	30	0.38	*
III	30	0.64	*
V	30	0.37	*
VII	30	0.33	NS

* - significant; critical value r = .3611

NS - Not significant.

Table XV shows significant correlation coefficients (0.38, 0.64, and 0.37) for standards one, three, and five respectifully. Length was an earlier acquisition than area among standard seven children.

The relationship between length and internal volume is indicated on table XVI.

TABLE XVI: Correlation Coefficients for length and internal volume:

STANDARD	N	CORRELATION COEFFICIENT	SIGNIFICANCE
I	30	0.28	NS
III	30	0.56	*
V	30	0.11	NS
VII	30	0.02	NS

NS - Not significant; * - significant, critical value r = 3611.

Table XVI shows a significant correlation for standard three only (r = 0.56). In the other standards, length was an earlier acquisition than internal volume.

Table XVII shows a comparison between the scores on area and internal volume conservation.

Table XVII: Correlation Coefficients for area and internal volume.

STANDARD	N	CORRELATION COEFFICIENT	SIGNIFICANCE
I	30	0.23	NS
III	30	0.42	*
V	30	0.29	NS
VII	30	0.18	NS

NS - Not significant, Critical value, r = .3611.

Again, as table XVII shows, it was only in standard three that a significant correlation coefficient was obtained (r = 0.42). Area was an earlier acquisition than internal volume in standards one, five and seven.

Sex Differences

It had been predicted that boys would perform better than girls on these conservation tasks. The data were analysed in terms of the number of boys and the number of girls who conserved each concept. A chi-square analysis was used to test whether the differences obtained were significant. Comparison was also made between boys and girls on the basis of actual scores obtained in each of the tasks. An F-test was used to **verify** whether the obtained results were statistically significant.

For each of these concepts means based on the raw scores had also been computed. These were used to plot graphs for comparing the performance of boys and girls.

Table XVIII shows the number of boys and the number of girls who conserved length.

Table XVIII: The number of boys and the number of girls who conserved length by standard.

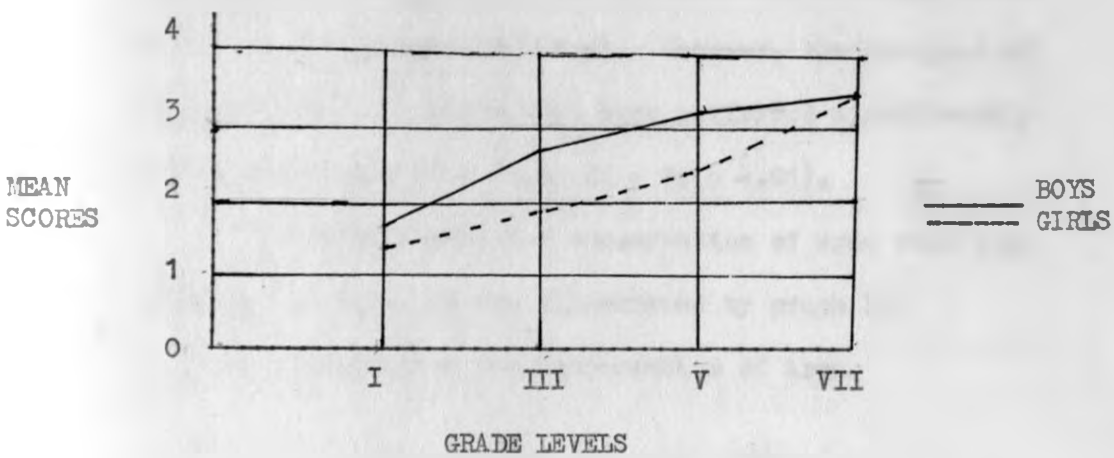
	GRADE LEVELS			
	SI	SIII	SV	SVII
BOYS	4	8	11	13
GIRLS	4	3	9	12

X^2 = 1.53; df = 3, 1; critical value = 7.8; p.05.

Although table XVIII indicates that there were not significant differences between the number of girls and the number of boys who conserved length (X^2 = 1.53; df = 3; 1; $p > .05$), the analysis of variance (table VI) showed that boys performed significantly better than girls on length conservation task (F = 4.10; df = 1; $p < .05$).

The mean scores for conservation of length task were presented in table V and are illustrated by graph I.

Graph I: Mean Scores for conservation of length.



Graph I shows that the greatest differences in performance on length conservation tasks occurred in standard three and five.

A comparison of the number of boys and the number of girls who conserved area is shown in table XIX.

Table XIX. The number of boys and the number of girls who conserved area by standard.

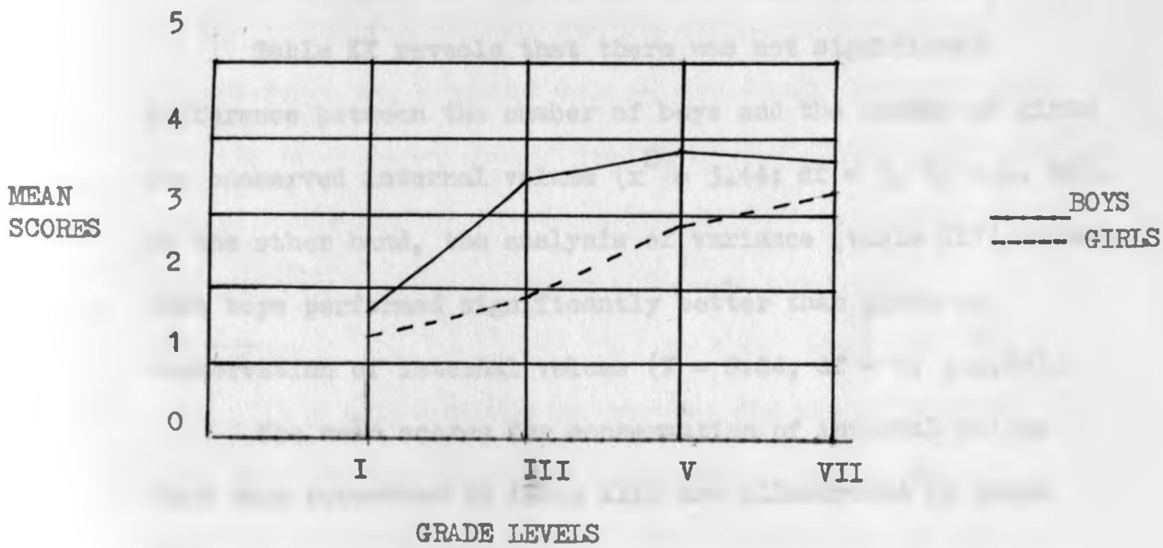
	GRADE LEVELS			
	SI	SIII	SV	SVII
BOYS	0	10	10	10
GIRLS	2	1	5	8

X^2 = 7.67; df = 3, 1; critical value = 7.8; p. 05.

Table XIX shows that the obtained value of $X^2 = 7.67$ was not significant since it does not reach the critical value of 7.8 at .05 probability level. However, the analysis of variance (table X) shows that boys performed significantly better than girls ($F = 11.3$; $df = 1$; $p < .01$).

The mean scores for conservation of area that were presented in table IX are illustrated by graph II

Graph II: Mean Scores for Conservation of Area.



Graph II reveals that the greatest differences in performance between boys and girls occurred in standard three and five.

The number of subjects who conserved internal volume is given in table XX

Table XX: The number of boys and the number of girls who conserved internal volume by standard.

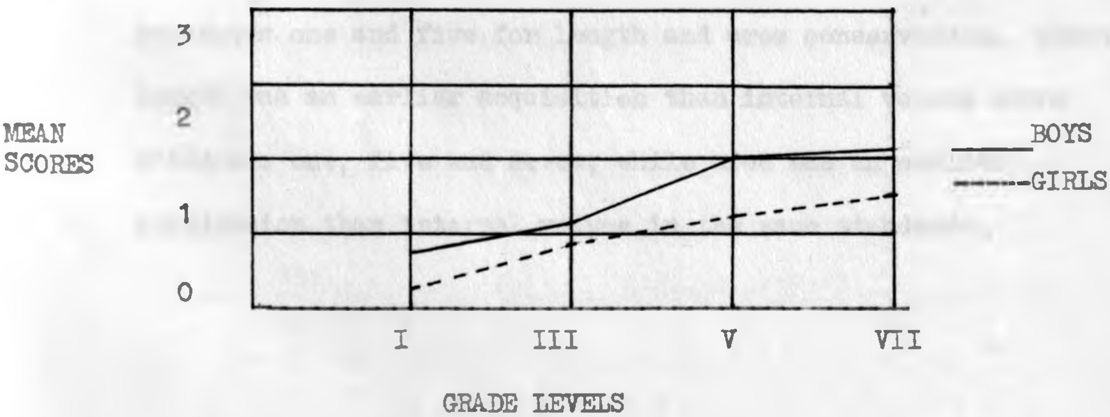
	GRADE LEVELS			
	SI	SIII	SV	SVII
BOYS	5	4	9	10
GIRLS	0	3	7	7

x^2 = 3.44; df = 3, 1; critical value 7.8; p. 05

Table XX reveals that there was not significant difference between the number of boys and the number of girls who conserved internal volume (x^2 = 3.44; df = 3, 1; p >. 05). On the other hand, the analysis of variance (table XIV) reveals that boys performed significantly better than girls on conservation of internal volume (F = 8.04, df = 1; p < .01).

The mean scores for conservation of internal volume that were presented in table XIII are illustrated by graph III.

Graph III: Mean scores for Conservation of Internal Volume



As graph III illustrates, the greatest differences in performance on internal volume occurred in standard five and seven.

Summary of the results

The results seem to indicate a developmental trend in that the number of children conserving significantly rose from lower to upper standards. This trend is also supported by the results of the analyses of variance which show that older children performed significantly better than younger children.

The chi-square analyses show no significant differences between the number of boys and the number of girls who conserved length, internal volume, and area. However, the analyses of variance reveal that boys performed significantly better than girls on all concepts. Thus, the hypothesis that boys would perform significantly better than girls was supported.

There was only partial support for the hypothesis that mastery of conservation of length, of area, and of internal volume is concurrent. For standard three, the correlation coefficients indicated simultaneous mastery of the three concepts. Simultaneous mastery was also evident in standards one and five for length and area conservation. However, length was an earlier acquisition than internal volume among standards one, five and seven, while area was an earlier acquisition than internal volume in the same standards.

CHAPTER FIVE

As was expected, children in upper standards performed better than children in lower standards on conservation of the three geometrical concepts. The answers and the justifications for these answers were similar to those given by Swiss children tested by Piaget. Thus, generally, the obtained results supported the Piagetian pattern concerning the conservation of Euclidean concepts.

It is evident from the results that these Kikuyu children lagged behind Swiss norms. Piaget had suggested that when 75 per cent of the children of a particular age group could successfully complete a task, it could be assumed that children of that age would normally be able to complete that task (Quoted by Otaala, 1973). According to this Piagetian criterion, conservation of length by girls was tenable at grade seven (mean age 13½ years) while by boys it was tenable at grade five (mean age 12½ years).

The results obtained on conservation of length were similar to those obtained among Banyankole children of Uganda (Okonji, 1970). The performance of the subjects in the present study was far better than that of Vernon's (1969) subjects.

On conservation of area, Piaget's criterion was not met, in that the tasks were not mastered by 75 per cent of the children in any of the standards. Girls performance was very low in that even in standard seven only 8 out of 15 mastered the concept. The results, on the whole, were similar to those obtained among the Pare children of Tanzania (Omari, 1972).

Similarly, conservation of internal volume was not mastered by 75 per cent of the children in any of the grades. Again, girls' performance was very low, on similar tests English children performed better than children in the present study (Lunzer, 1960; Lovell and Olgivie, 1961).

It seems that cultural props for the development of these geometric concepts are inadequate and school experiences do not fully rectify the situation. It is possible that lack of both manipulative and social experiences at home and at school may explain the low performance observed in the present study and in previous studies among African children (Vernon, 1969; Okonji, 1970; Page, 1973; Omari, 1973). Such an interpretation can be accommodated within the Piagetian theoretical analysis.

According to Piaget, Inhelder and Szeminska (1960), children who failed to conserve Euclidean concepts regard empty and occupied space as possessing elastic dimensions. However, the development of operational activity gradually enables the child, space is viewed as an all enveloping container, made up of a network of sites and subspaces where various measurements can be taken irrespective of whether the sites and subspaces are empty or occupied (Flavell, 1963).

Piaget has stated explicitly the role of action in the development of Euclidean concepts (Flavell, 1970). He maintains that adult cognitive representation of space derives from direct ontogenesis of actions performed upon objects rather that from a history of direct readings of their properties. This emphasis that children learn through actions implies that manipulative as well as social experience, whether at home or in school, affects the kind of thinking of which the child is capable and that the actual age when the mastery of certain concepts in attained is closely tied to children's experience.

Thus, it is possible that the socio-economic conditions that are experienced by these rural children may account for their low performance when compared to Swiss norms. Piaget (1950) suggests that social life is important for cognitive development in that social interaction is a necessary condition for transition from one level to another. Socialization is said to create stress that induces cognitive transformation. Piaget states.

> "Social life affects intelligence through the three media of language (signs): the content of interaction (Intellectual values): and rules imposed on thought (collective, logical or pre-logical norms)" (Piaget, 1950, p 156).

This interpretation may be relevant to the results of the present study. A noticeable feature of this rural community is poverty. Most of the adult males work for money wages to supplement the small income from their 'shambas'. A resultant feature is the absence of fathers from home. Consequently, mothers have to attend to their duties as well as those which were traditionally men's responsibilities. This means that women are generally over-burdened and, as a result, they do not have sufficient time to attend to their children's questions or to explain to them problems relating to the natural phenomena. Being so overworked could also make the mothers easily irritated by their children's curiosity and questions. This may not only hamper their children's intellectual development but may also affect the attitudes that children carry to the test situations. Children may tend to fear adult experimenters and this could be reflected in their performance.

Besides discouraging curiosity and interest in experimentation, lack of proper interaction between adults and children may encourage the perpetuation of an egocentric attitude, which, in Piaget's view, hampers intellectual development. According to Piaget, the social context encourages the child to acquire an objective view of the self and the world around him. Piaget implies this in the following statement:

> "Without interchange of thought and co-operation with others, the individual would never come to group his operations into a coherent whole; in this sense, therefore operational grouping presupposes social life" (Piaget, 1950, p 163).

The prevailing socio-economic conditions also affect the social and intellectual development of the children directly. Primary school children have to take part in economic activities from an early age. Boys usually assume their fathers' roles while girls perform most of the home chores. Children's time for play is restricted for according to their parents there are more important things to be done. Consequently, they do not have sufficient time to manipulate objects and observe them under different transformations. Besides these children are not always well-fed and overcrowding is common. These features imply lack of sufficient physical and mental vitality.

Previous speculations by investigators on non-western world seem to suggest similar problems. For example, Vernon (1965) suggests that the extent of self initiated play may affect mastery of conservation. He further speculates (Vernon, 1969) that lack of varied stimulation from the environment and lack of curiosity arising from lack of physical energy due to malnutrition or repression or frustration may affect congnitive development.

Similarly, Beard (1968) argued that Ghanaian children lagged behind their English counterparts because their environment was poorer, thus restricting their experience and because they did not use their mother tongue in school, a factor that is said to encourage rote learning.

Furthermore, Goodnow (1969) suggests that unity in the child's experience may be an important factor in performance on intellectual tasks. She argues that a child's performance may be poor if there is a split in the child's experience. She cites a split between school and the life outside. The school may not always encourage the child to trust his own experience and to bring to bear on school tasks all he knows.

Among these children, education (schooling) is regarded as the only means to a bright future. Success in life can only be guaranteed by passing school examinations. The teacher is regarded as somebody who hands out information to be absorbed, memorized and regurgitated on paper in the examination. Rarely is the child encouraged to find out facts by exploring and feeling the environment. The child does not know or does not believe that he can learn a lot by experimenting with the things around him. He does not realize that many tests require skill learnt through past informal experiences. Consequently, his experience is limited by the fact that there is a split between school and outside life. The child does well in tasks that depend on rote learning, but he may not excel on tasks like those on conservation that call for justification of ones answers, and reflection on ones past experiences rather than rote memory.

This is in line with Piaget's (1971) stipulation that we simply respect the laws of intelligence when we advocate that what the student learns comes from his own efforts instead of being imposed on him by the teacher, Piaget states:

> "his (pupil's) intelligence should undertake authentic knowledge from the outside" (Piaget, 1971, p 159).

Concurrent Conservation of length, area, and Internal Volume

According to Piaget Inhelder and Szeminska (1960), the conservation of length, conservation of area and conservation of internal volume are mastered concurrently. This concurrence is said to depend on the elaboration and co-ordination of the Euclidean operations of change of position and subdivision (Piaget, et al, 1960, pp 395). This formulation is associated with Piaget's general stand for a unitary and integrated developmental scheme centred around the development of logical and infralogical structures that facilitate the solution of a variety of related intellectual tasks (Pinard and Laurendeau, 1969, pp 137). The results of the present study do not fully support this formulation. Simultaneous mastery of the three concepts was evident only in standard three. Length and area were also found to be concurrent acquisitions in standards one and five but not in standard seven. Length was an earlier acquisition than internal volume, and area an earlier acquisition than internal volume in standards one, five and seven respectively.

These results partially support the findings of Beilin and Franklin (1962) and Omari (1973), which indicated that conservation of length like that of distance, is an earlier acquisition than the conservation of area. These investigators suggested that within the limits of a particular level, tasks that are ordered in difficulty because of complexity, for example, added dimensions, and which do not require any added operations for their solution, will be achieved in that order of complexity.

The results of the present study do suggest that the order of acquisition may be a function of the general familiarity of the problem or the teaching methods. Piaget has asserted that the role of action in the development of operations. It seems that the generalizability to an operation to the solution of different problems may be influenced by previous experience teaching methods used in school and the general familiarity of the problem.

In the present study, the child can refer to actions drawn from experience in play and in the performance of daily chores with twines and sticks, for the solution of conservation of length tasks. Problems related to area and volume are equally remote for these children. They rarely perform duties where they can gain relevant experience to the solution of area and internal volume tasks, hence their later acquisition. It seems possible that, teaching methods could help make up for this lack of experience. Probably, standard three children are forming the concepts simultaneously because they are exposed to New Mathematics where activity methods and manipulation of objects are encouraged, and these in turn are facilitating the generalizability of operations to the solution of many problems.

<u>Sex Differences</u>

As had been predicted, boys performed significantly better than girls on all conservation tasks. These results generally support the results obtained by Goldschmidt (1967) and Otaala (1973) who found that boys performed consistently better than girls on most of the conservation tasks which they used.

It seems possible, as Goldschmidt (1967) suggest, that, if boys have more opportunity to manipulate objects and perceive them under different transformation, their perfomance would excell that of girls. In the present investigation, this could be part of the explanation for the better performance of the boys. Girls, especially from the age of ten onwards, seem to be given more strenous responsibilities than their male counterparts. Since the mothers are usually busy in the garden or tending animals,girls have to perform all the home chores like cooking, drawing water, and taking care of younger children. Boys may help with the farm work but usually they look after animals which is a much lighter responsibility and besides it gives them more freedom to explore the environment.

Girls' playtime is more reduced than that of the boys. Thus they have less opportunity to manipulate objects and to perceive them under different manipulations. Lack of manipulative skills, plus physical exhaustion, may give rise to lack of mental vitality which, in turn, may affect performance on cognitive tasks, for example, conservation problems.

Another factor that could explain the poor performance of the girls on these conservation tasks is that their movements are more restricted than those of the boys. Mothers are reluctant to allow their daughters to wander away from home in case they become subjected to attentions of promiscuous men. Despite the good intentions, this restriction may stifle the girls' initiative and interest in exploration. Besides the chances of encountering with other social influences that would encourage the development of sociocentrism are reduced. Thus, girls may have less opportunities than boys to acquire objectivity which is essential for solution of cognitive problems. Lack of encounter with people from the outside world may render the girls more shy and diffedent than their male counterparts. It is possible that these characteristics could affect performance where the girls, like in the present investigation have to confront an outsider.

Again, in spite of the western influences, some families in the rural areas still maintain that girls should continue to accept their customary role in society. For example, they should learn to be obedient wives and loving mothers, their place being in the garden or in the home. They need not therefore, be very interested in being highly imaginative or in developing independent thinking. If the girls are conditioned to this attitude, their motivation may not be as high as that of the boys since their excellence is encouraged in other fields.

The tasks for area and internal volume conservation were the most difficult for the girls. The length conservation task was much easier for them probably because in their daily play or when performing their daily chores, they have more experiences with twine in stretched or coiled state. They use twine when skipping and they need it for trying firewood or water containers.

On the other hand, they are less exposed to actions related to conservetion of area and conservation of internal volume tasks. Boys more than girls play building houses using maize cobs or pieces of wood, or demarcating plots of land. They have opportunity to manipulate and perceive them under different shapes. Besides tasks for area and internal volume conservation that were used in the present investigation may have had more appeal to boys since they were more related to their day to day experiences and they were also some of the tasks that they will perform as adults.

Summary of Discussion

The results of the present study do suggest that the acquisition of these geometrical concepts may depend on skills obtained through social as well as manipulative experience at home and in school. Experience may also govern the generalization of operations to the solution of some concephial problems and not others. Further it may underlie sex differences in the mastery of these Euclidean concepts. Thus, we might need both Piaget's (1964) theory of antoregulation and Bruner's (1966) theory of internalization of technologies to explain children's understanding of geometrical concepts. However, more research is needed before meaningful conclusions can be made.

Some Educational Implications

The results of the present study seem to suggest that many among these primary schools have not mastered concepts that should have been acquired around the ages of seven and eight years. Failure to master these concepts possibly reflects lack of stimulating home environment and partly points to the problems and inadequacies of our primary schools. According to Castle (1966, p111) these problems include, inadequate equipment and unsuitable syllabi, among others.

Assuming that the results of this study can be generalized to the rest of the country, it would be wise to introduce topological and projective concepts in the lower classes to build up a firm foundation for understanding of Euclidean concepts.

Besides this change in the syllabus, it may be possible to induce these concepts by enriching children's experience. Activity methods should be encouraged and children should be allowed to manipulate materials whenever possible. The introduction of the New Primary Approach, in general, and New Mathematics, in particular, may help improve the situation. The role of the teacher should be to provide materials which children can manipulate, make models or draw, and pose problems and questions based on these materials as well as seek methods of solving them. The teacher should avoid using materials for demonstrations only as Piaget (1971) postulates that they encourage the child to regard configurations as more important than operations. A further way that would help induce attainment of these concepts is the introduction of group-work in the classroom. Piaget (1971) contends that cooperation impels the child to correct his egocentric attitude by enabling the child to see that other children see things differently from the way he views them.

Thus the results of the present study indicate that there is need for changes in the curriculum and teaching methods to cope with the noticeable developmental lag and also to help in inducing the acquisition of certain concepts.

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APPENDIX I

INTERVIEW SCHEDULE

CONSERVATION OF LENGTH

TASK ONE

Materials

4 sticks of equal length, 10 cm. long.

1 shorter stick, 9 cm. long.

1 longer stick, $11\frac{1}{2}$ cm. long.

1 cardboard 25.8 cm. x 22 cm.

Procedure

(Place the cardboard on the table and take out the six sticks). Here are six sticks. I want you to take out the longest, the shortest, and two that are equal in length. (Hand them to the subject). Give me the two equal ones and place the others on the table. I will place these on the cardboard like this: (Places them parallel on the marked space on the cardboard, in front of the subject with their ends coinciding). Now, tell me, are they the same length or is one longer than the other ? Why do you say so ?

(Push the stick which is nearer the subject so that it projects about 2 cm. beyond the other). Are the sticks the same length or is one longer than the other ? Which ? Why do you say so?

(Place the stick which had been moved in the previous step, in such a way that it is intersected by the other at right angles about 8 cm. from the end which is nearer to the subject). Now, are the sticks the same length or is one longer than the other? Why do you say so?

(Place the stick that had been moved in the previous steps, in such a way that it forms an angle of 30^{o} with the other. Repeat the above questions.

TASK TWO

Materials

Four pieces of chain, attached to a safety pin at one end.

2 chains equal in length, 14.5 cm.

1 chain shorter, 13.5 cm.

1 chain longer, 16 cm.

Procedure

(Take out the chains. Hand them to the subject). Show me two of the chains that have the same length, and one which is shorter, and one which is longer than the others.

(Stretch the two chains on the table, so that they are parallel and their ends are coinciding). Now, are the chains the same length or is one longer than the other? Why do you say so ?

(Bend the chain that is nearer the experimenter, Repeat the above questions).

CONSERVATION OF AREA

TASK ONE

Materials

1 cardboard rectangle, 9 cm. x 7 cm.

2 triangles formed by cutting a rectangle congruent to the above diagonally.

Procedure

(Take out the two triangles and the rectangle and give them to the subject).

Place these two parts (triangles) like this (in the form of a rectangle) on the table. Put this figure, (rectangle) on top and see if they are equal. (If the subject has problems in superimposing them, help him and have him look at all sides to see that the two rectangles are congruent. Then place the two rectangles side by side on the table in front of the subject). Now, tell me, is this piece the same size as that one or is one larger ? Why?
(Transform the rectangle made of two triangles into a triangle).

Is this piece the same as that one or is one larger? Why?

TASK TWO

Materials

Two cardboards each 25.8 cm. x 22 cm.

24 matchboxes

2 toy goats

Procedure

(Take out the two cardboards and give them to the subject). Place these two boards on top of one another and see if they are equal. (If the subject has difficulties in superimposing them, help him and have him look at all sides to see that the two are congruent. Then place the boards on the table side by side, in front of the subject.) Suppose that these two are fields and we want to plant some grass. Do we have the same amount for planting grass in this field as in that one ? Why ?

Now let us assume that we have planted some grass and each of us wants to keep a goat to eat grass. (Place a toy - goat in each of the fields, at one of the corners). Now, does this goat have the same amount of grass-covered as that one? Why?

We shall build a house in each of the fields. (Place one matchbox in each of the fields. Repeat the above questions. Place more pairs of matchboxes until there are twelve in each and ask the above questions, requesting a response justification only when there are two and twelve matchboxes in each field).

CONSERVATION OF INTERNAL VOLUME

TASK ONE

Materials

2 cardboards 25.8 cm. x 22 cm.

24 matchboxes

Procedure

(Show the subject the matchboxes and the cardboards). I am going to build a house for each of us and I want you to look at them very carefully. (Build a house in each of the cardboards in the form of 2 x 2 x 3 matchboxes). Now, tell me, is there as much room in this house as in that one ? Why do you say so? (If the response is that they are equal ask the following question): Which one can contain more things this one or that one ?

I want to build nine in another form. (Transform it in the form of 6 x 2 x 1 matchboxes.) Repeat the above questions. Then transform it in the form of 12 x 1 x 1 matchboxes. Repeat the above questions.

TASK TWO

Materials

40 matchboxes

2 cardboards used in the previous experiment.

Procedure

I am going to build one house for you in this field and four for myself in this field. I want you to look at them very carefully as I am going to ask you some questions concerning them. (Allow the subject 1 minute to look at them). I want you to select the houses among mine that have the same amount of room as yours. Then tell me why each is equal to yours. (After each choice ask the subject which house can contain more houses than the other and why ?

APPENDIX II

ABRIDGED INTERVIEW

BACKGROUND INFORMATION

Name ______________________

Sex ______________________

Age ______________________

Date of birth ______________________

Place of Residence ______________________

Father's occupation ______________________

Mother's occupation ______________________

Number of elder brothers (ask the subject to name them in each case) ______________________

Number of elder sisters ______________________

Number of younger brothers ______________________

Other people staying with the family ______________________

Father has other wives ______________________

How many ? ______________________

Number of children each has got ______________________

Number of rooms in the house ______________________

Subject has a room to himself ______________________

Shares with ______________________

Shares a bed ______________________

Subject allowed to play ______________________

Does he play ______________________

What does he play most of the time ______________________

Toys he uses ______________________

Language spoken at home ______________________

Languages the subject speaks ____________________

Languages the subject understands ____________________

____

What work the subject does after school ____________________

____

____

CONSERVATION OF LENGTH

TASK ONE

1. Now, tell me, are they the same length or is one longer than the other one ?

   Same ____________________

   Longer ____________ Which ? ____________________

   Why do you say so ? ____________________

____

2. Are the sticks the same length or is one longer than the other ?

   Same ____________________

   Longer ____________ Which ? ____________________

   Why do you say so ? ____________________

   ____

3. Now, are the sticks the same length or is one longer than the other ?

   Same ____________________

   Longer ____________ Which ? ____________________

   Why do you say so ? ____________________

   ____

4. What about now ? Are they the same length or is one longer than the other ?

Same ______________

Longer ____________ Which ? _______________

Why do you say so ? ______________________________

____

TASK TWO

1. Now, are the chains the same length or is one longer than the other ?

Same ___________

Longer ____________Which ? _______________________

Why do you say so ? _______________________________

____

2. Are they still the same length or is one longer than the other ?

Same _______________

Longer ________________ Which ? __________________

Why do you say so ? _______________________________

____

CONSERVATION OF AREA

TASK ONE

1. Now tell me, is this piece the same size as that one or is one larger ?

Same ________________

Larger ______________ Which ? ___________________

Why do you say so ? ______________________________

____

2. Is this piece the same size as that one or is one larger ?

Same ______________

Larger ______________ Which ? __________________

Why do you say so ? ______________________________

____

TASK TWO

1. Do we have the same amount of space for planting grass in this field as in that one or is one larger ?

Same ______________

Larger ______________ Which ? __________________

Why do you say so ? ______________________________

____

2. Now, does this goat have the same amount of grass - covered space as that one or is one larger ?

Same ______________

Larger ______________ Which ? __________________

Why do you say so ? ______________________________

____

3. Does this goat have the same amount of grass-covered space as that one or is one larger ?

Same ______________

Larger ______________ Which ? __________________

Why do you say so ? ______________________________

____

4. Does this goat have the same amount of grass-covered space as that one or is one larger ?

Same ______________

Larger ______________ Which ? ______________

Why do you say so ? ______________

____

CONSERVATION OF INTERNAL VOLUME

TASK ONE

1. A. Tell me, is there as much room in this house as in that one or is one larger ?

Same ______________

Larger ______________ Which ? ______________

Why do you say so ? ______________

____

b. Which one can contain more things ?

More ______________ Which ? ______________

Same ______________

Why do you say so ? ______________

____

2 a. Now, is there as much room in this house as in that one or is one larger ?

Same ______________

Larger ______________Which ? ______________

Why do you say so ? ______________

____

b. Which one can contain more things than the other one ?

More ________________ Which ? ____________________

Same ________________

Why do you say so ? ______________________________

____

3. a. Is there still the same amount of room in this house as in that one or is one larger ?

Same ___________________

Larger __________________ Which ? _______________

Why do you say so ? ____________________________

____

b. Which one can contain more things than the other ?

More ______________ Which ? ____________________

Same ______________

Why do you say so ? ____________________________

____

TASK TWO

1. Show me the houses among these four that are the same size as yours.

2 x 2 x 2 ______________

2 x 4 x 1 ______________

2 x 2 x 2 minus 1 on the top row __________________

2 x 2 x 2 plus 1 on top __________________________

Why did you choose it / them ? ____________________

____

2. Which can contain more things ?

More ____________________ Which ? ________________

None ____________________

Why do you say so ? ______________________________

____

APPENDIX III

RAW SCORES

Boys

Standard One 4, 1, 0, 2, 3, 2, 0, 1, 1, 4, 0, 3, 1, 1, 0.

Standard Three 4, 1, 4, 3, 1, 4, 1, 4, 4, 4, 1, 1, 4, 2, 1.

Standard Five 4, 2, 4, 4, 2, 4, 3, 4, 0, 4, 4, 4, 4, 1, 4.

Standard Seven 4, 1, 1, 4, 4, 3, 4, 4, 3, 4, 3, 4, 3, 3, 4.

Girls

Standard One 1, 3, 0, 0, 0, 1, 2, 0, 3, 3, 1, 3, 1, 1, 1.

Standard Three 2, 1, 2, 1, 3, 2, 2, 2, 1, 1, 2, 3, 2, 4, 1.

Standard Five 0, 2, 3, 3, 0, 4, 0, 3, 3, 4, 2, 3, 3, 4, 1.

Standard Seven 4, 3, 2, 4, 1, 4, 4, 3, 4, 3, 4, 1, 4, 4, 4.

CONSERVATION OF AREA

Boys

Standard One 2, 2, 0, 1, 3, 3, 3, 0, 3, 1, 1, 3, 3, 0, 1.

Standard Three 5, 3, 5, 4, 4, 4, 3, 4, 4, 5, 1, 2, 3, 4, 2.

Standard Five 4, 5, 1, 4, 4, 4, 3, 3, 2, 5, 4, 5, 5, 3, 4.

Standard Seven 5, 2, 3, 3, 4, 5, 3, 4, 4, 4, 2, 4, 2, 4, 5.

Girls

Standard One 0, 1, 0, 2, 0, 0, 3, 0, 0, 5, 1, 5, 2, 0, 0.

Standard Three 1, 2, 2, 2, 2, 2, 2, 2, 3, 2, 1, 2, 2, 4, 0.

Standard Five 1, 0, 3, 2, 2, 3, 4, 4, 5, 5, 4, 3, 3, 2, 3.

Standard Seven 5, 2, 0, 2, 4, 4, 5, 3, 3, 2, 5, 4, 2, 4, 4.

CONSERVATION OF INTERNAL VOLUME

Boys

Standard One	1, 0, 0, 0, 2, 0, 0, 0, 2, 2, 2, 0, 0, 0, 2.
Standard Three	1, 1, 3, 2, 1, 3, 0, 2, 1, 0, 0, 1, 1, 0, 0.
Standard Five	2, 1, 0, 3, 1, 3, 3, 2, 3, 3, 3, 3, 0, 2, 1.
Standard Seven	3, 3, 0, 2, 1, 3, 3, 3, 3, 0, 0, 1, 3, 3, 3.

Girls

Standard One	0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 1, 1, 0, 0, 0.
Standard Three	1, 2, 0, 0, 1, 1, 0, 1, 0, 0, 1, 1, 2, 3, 0.
Standard Five	2, 0, 0, 2, 0, 1, 2, 0, 0, 3, 2, 3, 2, 0, 1.
Standard Seven	2, 2, 2, 0, 3, 3, 0, 0, 2, 2, 2, 0, 0, 2, 2.