

دراسة الاختلافات بسبب الجنس في القدرة المكانية والتخيل العقلي وتحصيل بعض مفاهيم الهندسة في مرحلة العمليات الصورية لتلاميذ اليمن مهيب محمد علي عباد

ملخص : اهتم الكثير من الباحثين والتربويين وعلماء النفس بدراسة النمو المعرفي عند الأطفال وخصوصاً " بياجيه " الذي أكد على أن القدرة في اكتساب المفاهيم المكانية والتخيل العقلي المكانية والتخيل العقلي إنما تأتي تدريجياً وتلقائياً خلال تفاعل الطفل مع بيئته بينما اكتساب المفاهيم الرياضية الهندسية يحدث عن طريق التعليم المدرسي المنظم . وتعددت الدراسات في هذه الجوانب لتوضيحها أو لكشف جوانب أخرى مرتبطة بها وخصوصاً تلك الدراسات التي تبحث عن فروق بسبب الجنس للخاضعين للدراسة .

إن معظم الدراسات التي تبحث عن فروق بسبب الجنس أن لم تكن كلها فهي تؤكد على انه لا توجد فروق جوهرية ذات دلالة بين التلاميذ الذكور والإناث سواء في اكتساب مفاهيم المكان والتخيل العقلي أو اكتساب المفاهيم الرياضية الهندسية وإن كانت بعض هذه الدراسات تظهر أحياناً تفوقاً وإن لم يكن جوهرياً للذكور على الإناث في مرحلة العمليات الصورية formal operations مما شجع الباحث في موضوعه هذا على الكشف عنه ومعرفة نتيجته بين تلاميذ اليمن في نفس المرحلة .

أجرى الباحث دراسته على ٧٢٨ تلميذاً وتلميذة في مرحلة العمليات الصورية في مدارس مختلطة في محافظة عدن منهم ٣٨٠ ذكوراً ، ٣٤٨ إناثاً من خلال ثلاثة اختبارات في مفاهيم المكان العام والتخيل العقلي (كما هي عند بياجيه) وشكل كثير الأضلاع الهندسي (بنية المثلث والرباعي) .

نتيجة هذا البحث بعد معالجته إحصائياً أكدت بدلالة قاطعة انه لا توجد فروق جوهرية بين الذكور والإناث للطلاب اليمنيين في مرحلة العمليات الصورية لاكتساب مفاهيم المكان والتخيل العقلي او المفاهيم الرياضية الهندسية المدرسية

**Sex Related Differences In
Spatial Ability , Mental Imagery And Concept
Achievement In Geometry (Polygon)
Amongst Formal Operations Stage Pupils Of Aden
Governorate (Yemen)
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Abstract: Numerous authorities of investigators and educationists attracted to the Piagetian theory of cognitive development among children. Most studies were to find out relations of Piaget's Concepts of space and mental imagery acquired spontaneously with mathematics concepts acquired through formal constructions as well as to reveal other relations on sex-related differences for pupils who were going through Piagetian final stage formal Operations of cognitive development.

This work and its results encouraged the present investigator to do and reveal that for the Yemen pupils.

The investigator administered three tests in space, mental imagery concepts and geometry concepts (Polygon) for 728 pupil's (380 male and 348 female) of co-education schools in Aden Governorate (Yemen) were in the Piagetian formal operations stage .

The result statistically confirmed no significant differences were found between boys and girls in each of the three tests at the formal operations stage.

Introduction: Majority of psychologists investigating cognitive development among children, especially piagetians, hold that concepts are formed spontaneously in the child not only through the pre-school stage but also during the stage of schooling as well. The kind of concepts that a child acquires through the spontaneous efforts during the active involvement and interaction with the world may therefore be identified as basic or fundamental concepts (e.g. concepts of space). While the level of conceptual maturation of the child by assessing the level of acquisition of these basic concepts and identifying its relationship with the level of concepts acquired in specifically designed teaching - learning situations (e. g. concepts of geometry), we may well arrive at such an understanding that can help us to put the two kinds of concepts in consonance with each other. As concepts of space including mental imagery are formed gradually and spontaneously through interaction in the world around, these concepts would be the basic concepts, while on the other hand, geometrical concepts, are acquired

through deliberate teaching or through formal instruction and hence they would be achieved concepts. Accordingly, the new trends of mathematics education and of curriculum in the last three decades in the world around, the main emphasis has been on conceptual learning.

Concurrently, mathematics educators too started taking a serious interest and began to concern themselves with the problem of unravelling the relationship between spatial abilities and mathematics achievement. Most studies supported the existence of positive and significant relationship between spatial abilities and mathematics achievement in general and achievement of geometry in particular. Siegvold (1944) found strong evidence in the relationship between space visualization and geometry achievements. Smith with his associates (1948, 1954) also found a higher correlation of spatial tests with examination scores in geometry than with arithmetic and algebra. Barakat (1951) administered a battery of tests on two equal groups (age range 12+ to 14+ years), one normal and the other retarded in mathematics, and found that ability on spatial tests correlated more highly with ability in geometry than in algebra, and the pupil retarded in mathematics appeared to be deficient in spatial abilities. MacFarlane Smith (1964) argued that spatial ability was essential for mathematical achievement. Fennema and Sherman (1977) provided support for this conclusion, they found that the correlation between mathematics achievement and spatial visualization were approximately as high ($r = 0.5$) as the correlation's between mathematics and verbal ability.

Studies in USSR as well as studies in other non-English speaking countries, led to similar findings that spatial abilities have significant relationship with mathematics achievement in general and with geometry in particular. Krutetskii (1976) reported that 57% of the teachers assessed the spatial ability as a determinant of mathematical achievement in school children, and observed that "you can't take a step in geometry without this". He considered mathematics as "the science of numerical relations and spatial forms", and concluded that, "an ability for spatial concepts, which is directly related to... Geometry (especially geometry of space) is one of the component of mathematical abilities".

Numerous authorities on the basis of their studies observed that up until adolescence, girls and boys show no more difference in mathematics achievement than they show in general intelligence. It has been argued that girl, marked decline in mathematics achievement at adolescence is linked to deficiencies in spatial ability. Maccoby and Jacklin (1974) reported that at approximately 13-14 years old, boys begin to perform at higher level than

girls and they tend to increase this advantage throughout their adolescent period. A study was conducted by Mirza (1975) for 48 adult subjects (24 with formal schooling up to tenth grade and 24 with post secondary education) and the subjects with each educational category were grouped into two age groups viz. Younger group with 18-25 years and the older group of 26 years and above with an equal number of men and women in each category. The findings indicated that no significant differences existed on the basis of age and sex on Piaget's pendulum test and Piaget's liquid test except in the case of vocabulary subject of Wechsler Adult Intelligence Scale (WAIS) where age was significant ($p < 0.05$).

Other studies were also conducted by Basmajian (1978), Seip (1979), Stallings (1979), Sherman (1980) and Smith (1980). Basmajian's (1978) data collected from a total of 83 junior students led to the following conclusions: (i) formal operational students achieve at a significantly higher level than do non-formal operational students, (ii) although results indicate that the male students did consistently achieve at a higher level than females, gender did not significantly affect the level of achievement, (iii) age was not a significant factor in the level of achievement attained by students in either cognitive group (Basmajian, 1978). Seip (1979) administered three mental imagery tasks on a sample of 60 children aged 6 to 11 years to analyze the relation between static or reproductive and anticipatory mental imagery as defined by Piaget and Inhelder (1971). He reported that in each task significant sex differences were not obtained. While Stallings (1979) reported that spatial ability distinguished between those girls who continued their mathematical study and those who did not (Stallings, 1979). Sherman (1980) found that spatial visualization scores were more highly predictive of mathematical attainment for girls than for boys (Sherman, 1980). Smith (1980) conducted his investigation on 722 students enrolled in the science classes of three high schools, the students were classified as concrete operational, transitional, or formal operational. The results indicated that there was a significant relationship at the 0.05 level between scholastic achievement and Piagetian stages of cognitive development and the students who were formal operational tended to receive higher scholastic grades in science than those students who were concrete operational or transitional. The findings also revealed that there was no significant difference between the sexes regarding their cognitive developmental stages or their scholastic grades (except in physical science).

For mathematics achievement and spatial abilities, Ben-haim (1982) took a sample of 430 subjects from VI, VII and VIII grade students to study sex differences in spatial visualization abilities and attitude towards

mathematics before and after instructional intervention . The results prior to instruction were significant that, (i) grade differences in spatial visualization performance (increasing with age) and in attitudes towards mathematics (decreasing with age) , (ii) sex differences in spatial visualization performance (favouring boys) , but no sex differences in attitudes towards mathematics , and (iii) site differences in spatial visualization performance ; as the socio-economies status rose , the performance increased . After the instruction: (a) the subjects (both boys and girls) performed significantly higher on the spatial visualization test, though on change in attitudes toward mathematics occurred, (b) boys and girls gained similarly from the instruction, inspite of initial sex differences, (c) students' attitudes toward mathematics and spatial visualization were similar , (d) grade differences (decreasing with age) in attitudes spatial visualization were found , but no sex differences and (e) retention of effects persisted .

Tartre (1984) intended to explore the role of spatial orientation (SO) skill (which requires that the subject readjust his perspective to become consistent with a representation of an object presented visually) in the solution of mathematics problems and to identify possible associated sex-related differences. Form a random sample of 97 tenth grade students, a sample of 57 students who scored high or low on the Gestalt completion test was selected to be interviewed. Those 57 students (30 females, out of them 13 high SO and 17 low SO , and 27 males , out of them 14 high SO and 13 low SO). Data indicated that SO skill was involved in understanding a mathematics problem and linking new problems to previous work. High SO females achieved as well or better than the male group. However, the low SO females scored lower than the other groups on mathematics achievement and for many tasks involved in solving mathematics problems.

Boldwin (1984) investigated experimentally if practice effect due to training in spatial skill could be demonstrated, and if these effects transferred to improve mathematics achievement for a sample of 88 at Vth and VIth grade students in four intact classes from two schools. The results indicated that (a) spatial skills of the sex students can be improved through instruction ($p < 0.01$), (b) there is no evidence that sex differences are associated with spatial ability at this level if pretest information is taken into consideration, (c) instruction in spatial skills can significantly improve the performance of female subjects ($p < 0.01$) , (d) instruction can significantly improve the performance of subjects of either sex with medium ($p < 0.01$) or low ($p < 0.11$) spatial ability , and (e) there is a positive linear relationship between mathematics achievement and spatial ability but instruction in the latter had no effect on mathematics achievement for the total students

sample or for students of low, medium, or high spatial ability taken separately.

In view of the preceding studies and realizing that the spatial and cognitive abilities are not two of significant intellectual abilities only but also these have a determining effect upon geometry achievement, therefore, the understanding and application of the denoted abilities not only suggest as means of facilitating a better match between the curriculum and the mental abilities of the learner, but also suggest viable determiners of scholastic achievement in geometry (Mahyoob, 1989).

Though there is a sufficient evidence of no sex-differences, yet some evidence on the contrary calls educators to explain observed low scores of most girls on spatial tests as a determiner of low performance on achievement in mathematics. This led to this investigation with the following objectives.

Objectives:

This study as a pioneer one in Yemen aimed at revealing whether there exist sex-related differences in mental imagery, spatial abilities and concept achievement in geometry for Aden Governorate pupils at the formal operations stage, of age-groups 11 to 16+ years.

Hypotheses:

The main hypotheses of this study was there exist significant differences between boys and girls in favor of boys at the formal operations stage of Aden Governorate pupils (Yemen) in all the tests of mental imagery, spatial concepts and concept achievement in scholastic geometry.

Tools:

The tools were three tests: adapted, developed and constructed for Arabic medium pupils from Piagetian experiments (56,60 and 71) and other replication studies as well as from tests developed by Mahyoob (1989). These tests were:

I - Test of Concept Achievement in Geometry (polygon - Triangles and Quadrilaterals, exclusively as contained in our text-books) to measure the pupils, handling of various concepts in polygon components. For this purpose 104 items were constructed on the basis of Ganges hierarchical structures of prerequisites and capability concepts and contained four sub tests were (a) Basic concepts related to elements of a polygon -34 items, (b) Concepts related to properties of a triangle - 22 items, (c) Concepts related to properties of quadrilateral -20 items, and (d) Relations between polygons

(triangles and quadrilaterals) -28 items. All these items were of completion, true-fles, matching and multiple choice varieties.

II- Test of maturation of General Space Concept on the basis of Piagetian experiments -35 items. These items were classified into topological -7 items, projective -9 items, and Euclidean -19 items. All these items were of three or four alternatives.

III-Test of maturation of Mental Imagery Concept on the basis of Piagetian experiments - 68 items. These items were classified into four constituents: Anticipatory Transformation Images of product - ATP (30 items), Anticipatory Transformation Images of Modification - ATM (10 items), Kinetic Anticipation of product - Akp (18 items), and Kinetic anticipation of Modification - AKM (10 items). All these items were of four alternatives.

Procedures:

Test try-out: All of the three tests were compiled after a test try-out on a sample of pupils at the formal operations stage in an area schools not so far of the districts where the actual test schools will be selected, adopting the usual criteria of difficulty and discrimination indnices to select items for the final forms.

Final forms of administration: The investigator planned to select test schools, administrate the tests and to perform other requirements by helping and advice of his colleagues, test schools teachers and other concerned and experienced educationists of Aden Governorate. The three tests were administered during one school day for each class in which these classes were in the base of even numbers to be selected. Four test sessions were held with ten minutes gap between two sessions.

Sample:

The study was conducted on five government co-education unity schools at two districts represented about half of the school number of one province out of three provinces form the Aden Governorate. These schools were suggested by experienced and concerned educationists of General Directory of Education Aden Governorate to be selected that was to give a good representative of the eco-social and cultural status of the society. The sub-samples were selected at VI, VII and VIII grade level of each school belonging to age group 11+ to 16+ that is of formal operational stage. The total of this sample was 728 students, out of these 348 were girls and 380 were boys. The following table (1) shows the distribution:

Table (I) showing this Sample Distribution

Grade	Boys	Girls	Total
VI	132	121	253
VII	121	112	233
VIII	127	115	242
Total	380	348	728

Result:

TO identify whether the boys or the girls of the formal operational stage were better or equivalent to the others in spatial ability, mental imagery and concept achievement of polygon; the statistical analysis of the data collected is shown in the following table:

Table (II)- showing the statistical analysis of the data collected

Test	Group	No-of cases	Mean	S.D.	Standard Error	t value	df 2-tail	prob.
Mental Imagery	Male	380	26.8395	10.099	0.518	0.90	726	0.366
	Female	348	26.1839	9.338	0.503			
Space	Male	380	14.7763	5.379	0.276	1.33	726	0.183
	Female	348	14.2845	4.500	0.241			
Geometry ach.	Male	380	39.7710	16.551	0.849	0.16	726	0.875
	Female	348	39.5805	16.058	0.861			

Therefore, to unravel whether the two groups differ significantly in mean performance to enable us to say with confidence that there is a difference between the means of the populations from which the two samples were drawn, the statistical computations in the above table (II) for the three variables showed that:

- (i) Mental imagery t-value was 0.90 which for df 726 is less than 1.96 therefore, no significant difference exists in acquisition of mental imagery concepts between girls and boys of Aden Governorate school students for the sample at formal operational stage of VI, VII and VIII grade levels.
- (ii) Again, space concept t-value was 1.33, for df 726 is less than 1.96, therefore, no significant difference exists in acquisition of space concept between girls and boys of Aden Governorate school students for the same sample at formal operational stage.

- (iii) Lastly, concept achievement of polygon t- value was 0.16, for df 726 is less than 1.96, therefor, no significant difference exists in acquisition of concept achievement of polygon for the same sample at the formal operational stage.

Conclusion:

Firstly, the pervious related studies, showed that:

- (a) There is a strong evidence in the relationship between spatial ability and Geometry achievement, as in the studies of Siegvold (1944), Smith and His associates (1948, 1954 and 1964) and Fennema and Shaman (1977).
- (b) Spatial ability is one of the components of mathematical ability especially geometry of space and considered as a determinant of school Mathematical achievement as in the studies of Krotetskii (1976) and Mahyoob(1989).
- (c) At adolescence period which is nearly corresponding the formal operational stage at Piagetians, boys begin to perform at a higher level in mathematics than girls , where other authorities refer that to girls ' deficiencies in spatial abilities at this period as in the studies of Maccoby and Jacklin (1974), Basmajian (1978) , Smith (1980) and Ben -Heim (1982) . This is why as mentioned earlier sex-related differences in spatial abilities as well as in achievement of geometry is still an open one.

Secondly, this study based on a sample of Yemeni pupils at Piagetian formal operational stage confirmed that:

At this period, there is no significant differences in each of spatial concepts, mental imagery concepts and concept achievement of scholastic geometry between boys and girls of Aden Governorate, that is , the main hypothesis is rejected . Also this result evaluates the opinion that boys begin to perform at a higher level in mathematics than girls where some authorities referred that to girls ' deficiencies in spatial abilities at this stage.

As well as the positive result of this study may be due to the effect of the wide and comprehensive concepts of modern mathematics where our school textbooks are described as rich with spatial ability concepts. At the same time, the investigator suggests other follow up studies to find out interpretations that high percentage of secondary school girls join the Art Section, whether as a self desire or as negative attitudes towards mathematics or something else.

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ورد البحث للمجلة في ١٩٩٦/٤/٢٥ أعيد البحث بعد تعديله في ١٩٩٧/١١/١٨ أجزى البحث للنشر في ١٩٩٧/١٢/٢٨