

The Relationship Between Cognitive Development and School Achievement

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One of the most comprehensive theories in child psychology is piaget's theory of cognitive development. There has been a great interest in this theory on an international scale and there is a huge volume of cross-cultural studies testing the validity of this theory (e.g., Dasen, 1977; Ginsburg, 1972). This introduction does not intend to review or summarize Piaget's theory. The reader can find some excellent sources (e.g., Brainerd, 1978; Flavell, 1963; Furth, 1969; Ginsburg & Oppen, 1978). Few words will suffice here about the philosophy behind this theory.

Piaget's main theme from the early 1920's up till now is to answer the question of how humans acquire knowledge. He has found out that the best way to answer this question is to study how children start to acquire knowledge and how they develop it. In his theory, Piaget borrowed heavily from his rich background in zoology and philosophy. The system he has developed is called genetic epistemology because of the biological presuppositions from which it stems and the epistemological consequences in which it ends (Piaget, 1970).

This paper is interested in two aspects of Piaget's theory both of which have received a great deal of attention from Piagetian Psychologists. The first is that of using tasks derived from Piaget's theory to predict school performance. The question is: If we administer certain Piagetian tasks to school children, will the knowledge of their performance on these tasks help teachers know better about the children's performance in school subjects ?

Research in this area suggests that a moderate but significant correlation does exist between the cognitive level of children as measured by Piagetian tasks, and school achievement as measured by teacher-made tests or standardized achievement tests (Bearison, 1975; DeVries, 1974; Dimitrovsky & Almy, 1975; Goldschmid & Macfarlane, 1968).

The present study measures cognitive level in children by using five Piagetian tasks: Transitivity of weight, conservation of number, conservation of area, conservation of weight, and multiple classification.

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ABSTRACTS

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Children's school preformance is their row scores in Arabic and arithmetic in their mid-year grades estimated by their teachers.

The other aspect of Piaget's theory that of great interest to developmental psychologists is his notion of synchrony and sequence in the stages of cognitive development, especially at the concrete operational level (For more details about the characteristics of Piaget's developmental stages see Saleh, 1977). Piaget assumes that cognitive items germane to the concrete operational period develop synchronously, that is, concurrently, because the eight groupment that lie at their base are logically and psychologically interrelated (Peterson, Hooper, Wanska, & Defrain, 1976). A specific example here is Piaget's contention that transitivity of weight, conservation of number, conservation of weight, and class inclusion are mastered by children at about the same time. Moreover, Piaget theorizes that violations of these rules are minor fluctuations he calls horizontal decalage. These are, however, some recent studies with seriously challege the Piagtian claim (Brainerd, 1974; Peterson et al., 1976; Poussaint, 1974). The findings of these studies support a definite sequence of appearance for these Piagetian tasks. The order of appearance is: Transitivity, conservation, second, and class inclusion last.

The present study is an attempt to see if four Piagetian tasks used appear synchronously as Piaget states or there is a sequence in the order of their appearance as Brainerd and others contend. The four Piagetian tasks of interest here are: transitivity of weight, conservation of number, conservation of area, and conservation of weight.

Hypothesis 1:

The performance of first and third elementary school children on transitivity of weight, conservation of number, conservation of area, conservation of weight, and multiple classification is positively correlated with the same childrens' school achievement in Arabic and arithmetic. The correlation between the childrens' cognitive level as measured by Piagetian tasks and school achievement is moderate and significant.

Hypothesis 2:

First and third grade children master the Piagetian tasks in the following order: Transitivity of weight (easiest), conservation of number, conservation of area, and conservation of weight. Conservation of weight is the most difficult. The null hypothesis of approximately equal difficulty among these tasks is rejected.

Method

Sample and Population:

One hundred fifteen (115) female children are drawn randomly from two female elementary schools in Kuwait to participate in the study. The two schools belong to the Ministry of Education in Kuwait. First and third graders participate in the study. There are 70 first graders who are randomly selected from a pool of 16 sections in the two schools. Forty six (46) first graders are randomly picked up from school A and 24 first graders are randomly selected from school B. Forty five (45) children are randomly selected from 10 sections in grade three in school A. The mean age in months for the first graders is 83.771, and the mean age for third graders is 108 months. The mean age for both groups is somewhat high due partly to the fact that the administration of the tests took place approximately before the end of the school year. All the children in this study are tested in the same week by 4 psychology majors who were trained on this kind of testing. Two examiners tested the children in each school. The children in this study belong to different nationalities. The whole sample includes 68 Polestinians-Jordanians, 32 Kuwaitis, and the rest came from other Arab countries. Most of the children came from middle to lower middle social classes. The average number of children in the family in this study is 6.

Tasks:

Five Piagetian tasks are administered in this study. They are: Transitivity of weight, conservation of number, conservation of area, conservation of weight, and multiple classification. All of these tasks are similar to the ones used by Piaget and by Piagetian researchers. The way these tests are constructed follows the Guttman scale method or scalogram (Edwards, 1957; Guttman, 1944). These types of tests are called ordinal scales (Anastasi, 1976). The Guttman scale is used to order a group of items or tasks with a common content into a linear hierarchy and to evaluate whether or not this hierarchy is unidimensional and cumulatively hierarchical (Bart & Arisian, 1974). This means that if an individual gets an item or task correct, that same individual should be able to pass all the items or tasks that are ranked as less difficult. The inverse is also true, that is, a hierarchy is judged unidimensional and cumulative if failures on an item or task co-occur with failures on items or tasks ranked as more difficult (Bart & Arisian, 1974). If these conditions are met then the scale constructed is said to

have a perfect coefficient of reproducibility (+ 1.00). However, in order for an ordinal scale to be considered suitable it has to have a minimum of .85 coefficient of reproducibility (For more details about the Guttman scale and how to compute the coefficient of reproducibility, see Edwards, 1957; Guttman, 1944).

The five Piagetian tasks used in this study meet the scalogram analysis criteria. Two of these tasks (The conservation of number, and multiple classification can be found else-where (Feky & Saleh, 1978). However, two modifications were introduced to the two tasks in order to fit the new sample. In the conservation of number task, the number of buttons used is 8 instead of 4 in the earlier study. In the classification task, the number of dimensions tested in the present study is 3 (color, size, and shape) instead of two dimensions used in the earlier study. The other three Piagetian tasks used can be found in Appendix A, Appendix B, and Appendix C. The five tasks are administered to each child individually in one session. The order of presentation of these tasks is randomized in order to avoid order effect. Two examiners are present during the testing of each child. The responses the child give are recorded by one of the examiners on forms similar to those in the Appendixes. The maximum score any child can achieve on each of the Piagetian tasks given is as follows:

Task	Maximum Score
1. Transitivity weight	6
2. Conservation of number	8
3. Conservation of area	8
4. Conservation of weight	4
5. Multiple classification	6

School achievement is measured in terms of the cumulative score the child has obtained up till mid-year in Arabic and arithmetic. These academic achievement scores are estimated by the classes teachers. Maximum achievement scores are 20 in Arabic and 20 in arithmetic for first graders. Maximum scores for third graders are 40 and 40.

Results

Four types of computer analysis were performed on the data collected. The first analysis was performed on the whole sample of 115 children that participated in the study. Table 1 includes the intercorrelational matrix, standard deviations (S.Ds.), and skewedness

indices of the variables studied. The Table also shows that measures obtained on the Transitivity of weight task are not included in the analysis. As a matter of fact they are not included in any of the analysis performed in this study. The reason for not including the results from the Transitivity of weight is due the ceiling effect of the scores obtained on this task-more than 97% of all children tested achieved perfect score on this task.

Looking back at table 1. One can notice that three Piagetian tasks (Conservation of number, conservation of area, and conservation of weight) correlate moderately but significantly with school achievement in Arabic and arithmetic ($P < .05$ to $P < .01$). The hypothesis of a positive moderate and significant correlation between the cognitive level and school achievement is supported for 3 out of 5 Piagetian tasks when the data from the whole sample are analyzed.

The second analysis was carried out on the data collected from first graders in both schools ($N = 70$). Table 2 shows the results of the analysis in terms of an intercorrelational matrix, means, S.Ds., and indices of skewedness for the variable in this subsample. In Table 2, one can notice that the hypothesis of a positive, moderate and significant correlation between conservation of number, conservation of area, and multiple classification on the one hand, and achievement in Arabic and arithmetic on the other hand was supported ($P < .05$ and $P < .01$). However, the correlation between the conservation of weight and school achievement was not significant for first graders.

Table 3 includes the results of the analysis of the data collected from third graders. This table shows that only the conservation of weight task is significantly correlated with achievement in Arabic ($P < .05$) and with arithmetic ($P < .01$).

Thus if we consider the third graders only, then the only hypothesis supported is the part dealing with the relationship between the conservation of weight and achievement in Arabic and arithmetic.

Table 4 shows the results of the analysis of the data collected from first graders in school B, ($N = 24$). Three Piagetian tasks used in this study (Conservation of number, conservation of area, and multiple classification) and the sum of the scores of these three tasks correlate moderately high with measurements of school achievement in Arabic and arithmetic, thus supporting the hypothesis of a positive and

significant relationship between the child's cognitive level and his academic achievement. It is clear from Table 4 that the conservation of weight task does not correlate significantly with performance on school subjects.

The final step in the analysis was performed to answer the question of synchrony in Piaget's theory. Table 5 shows the frequencies and percentages of the children in the whole sample who mastered (Passed) each of three Piagetian tasks (Conservation of number, conservation of area, and conservation of weight). Transitivity of weight was excluded because the ceiling effect mentioned earlier. A score is considered pass if the child obtains a perfect score on the Piagetian task. Looking at Table 5 again, one notices that the order of difficulty, from the easiest to the most difficult goes as follows: Conservation of number → conservation of area → conservation of weight.

But the question is: Are these differences in the number children mastering each of the three tasks statistically significant? To answer this question a χ^2 test suggested by Cochran (Hays, 1963) is applied. The test is appropriate in studies involving repeated observations (or matched groups) where the dependent variable can take only two values: 1 for pass or success and 0 for fail. When this test is applied, here the χ^2 value turned out to be 87.53 which is significant at the .001 level for two degrees of freedom. The hypothesis of no difference in difficulty among the three Piagetian tasks is rejected. Another comparison was made between the conservation of number and the conservation of area tasks both of which seem to be of approximate difficulty. When these two tasks were compared the χ^2 value is 13.81 which is significant at the .01 level for one degree of freedom. Thus the hypothesis of no difference in difficulty between the conservation of number and the conservation of area is rejected. No further comparisons are needed since the differences between the conservation of weight on the one side and the conservation of number and area on the other side are very large.

DISCUSSION

The findings of the present study support previous findings of a positive moderate and significant correlation between the cognitive level of the child measured by Piagetian ordinal scales and school achievement measured by the child's performance on teacher-made or

standardized tests. However, there are few qualifications that should be spelled out concerning this study. First, the transitivity of weight task is not a good predictor of academic achievement for either first or third graders because this task turned out to be too easy for both grade levels and hence we have a ceiling effect. The same objection can be raised against using conservation of number, conservation of area, and multiple classification with third graders.

Another limitation in using Piagetian tasks to predict performance in school can be seen from studying the relationship between the conservation of weight and academic achievement. Table 2 shows that the correlation between the conservation of weight and school achievement was not significant for first graders, while the relationship was significant for third graders.

The conservation of weight is a poor predictor of academic achievement because this task is too difficult for first graders. Only 16% of the first graders mastered the task (See Table 5). On the contrary though, the conservation of weight is an excellent predictor of school achievement in arithmetic and Arabic in the third grade.

The problem of deciding on the level of difficulty of the task for certain age or grade level can be facilitated by studying the indices of skewedness (Table 2 & 3). For example, the conservation of number task is easy for first graders because it has a high index of skewedness, 1.912 (See Table 2). This can be noticed clearly from table 5 where the percentage of first graders who mastered the number concept is 80%. The number task is even easier for the third graders where the index of skewedness is -2.958, (very high), and the percentage of third graders' who mastered it is 91%.

In conclusion then, the transitivity of weight is not a good predictor of school achievement for either first or third grade unless it is modified to make it more difficult. The same thing can be said about administering the conservation of number, conservation of area, and multiple classification for third graders. The best predictive results can be obtained if we administer the transitivity of weight to kindergarten children, Administer the conservation of number, conservation of area, and multiple classification to kindergarten and first grade children. Conservation of weight should be used after the first grade.

The data in this study do not support Piaget's theory of synchrony during the concrete operational stage. There are differences in the numbers and percentages of children who master each task. The largest

number perform correctly on the conservation of number (95), while those children who have the conservation of area correct are 74 which is less than 95. The least number of children are able to conserve weight (28 children). It is to be noticed that we are using the same sample (N = 115) and hence a child may be conserve none, any, or all of these tasks. The numbers just mentioned tell us that the order of difficulty for these three Piagetian tasks (from easiest to most difficult) are: Conservation of number, Conservation of area, Conservation of weight. When the Cochran test is applied to the data collected on both grades, the hypothesis of no difference in difficulty among the three Piagetian tasks is rejected thus giving an additional negative proof against the idea of synchrony.

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Table 1

Intercorrelational matrix, means, standard deviations (S.Ds), and indices of skewedness of the variables studied using 1st & 3rd graders.

Variables	School	Grade	Examiner	Age	School Achievement		Piagetian		Tasks	
					Arabic	Arithmetic	Number	Area	Weight	Classification
School	1.00									
Grade	-.412***	1.00								
Examiner	.417***	.088	1.00							
Age	-.314***	.092***	.092	1.00						
Arabic	-.328***	.787***	.249***	.731***	1.00					
Arithmetic	-.266***	.700***	.238***	.648***	.811	1.00				
Number	.066	.203*	.233**	.235**	.251***	.290***	1.00			
Area	.008	.063	-.071	.077	.168	.266**	.372***	1.00		
Weight	-.033	.370***	.229**	.330***	.423***	.456***	.293***	.060	1.00	
Classification	.247***	.113	-.134	.023	-.125	-.032	-.141	-.119	-.035	1.00
Means	1.209	1.391	2.870	95.043	19.687	18.939	7.157	6.165	1.235	4.348
S.Ds.	.408	.490	1.399	15.282	9.547	9.347	2.024	2.705	1.713	1.534
Skewedness	1.434	.445	.060	.592	.972	1.147	-2.413	-.050	.840	-.840

* P < .05

** P < .02

*** P < .01

Two-Tailed test

Table 2

Intercorrelational matrix, means, S.D.s., and indices of skewedness of the variables studies using data collected from 1st graders N = 70.

Variable	School	Examiner	Age	School Achievement			Piagetian		Tasks	
				Arabic	Arithmetic		Number	Area	Weight	Classification
School	1.00									
Examiner	.799 ^{***}	1.00								
Age	.324 ^{***}	.237 [*]	1.00							
Arabic	-.015	.096	.352 ^{***}	1.00						
Arithmetic	.095	.209	.190	.721 ^{***}	1.00					
Number	.179	.364 ^{***}	.247 [*]	.290 ^{***}	.352 ^{***}	1.00				
Area	.025	.125	.182	.361 ^{***}	.365 ^{***}	.482 ^{***}	1.00			
Weight	.200	.114	.101	.123	.165	.250 [*]	.051	1.00		
Classification	.313 ^{***}	.110	.281 ^{***}	.262 [*]	.289 ^{***}	.217	.272 ^{***}	.146	1.00	
Means	1.343	2.771	83.771	13.686	13.714	6.829	6.029	.729	4.486	
S.D.s.	.478	1.119	4.440	3.010	3.311	2.395	2.839	1.444	1.391	
Skewedness	.662	-.354	.186	-.379	-.359	-1.912	-.998	1.618	-.459	

* p < .05
 ** p < .02
 *** p < .01
 Two-Tailed Test

Table 3

Intercorrelational matrix, means S.Ds., and indices of skewedness of the variables studied using data collected from 3rd graders. N = 45.

Variable	Age	School Achievement		Piagetain		Task	
		Arabic	Arithmetic	Number	Area	Weight	Classification
Age	1.00						
Arabic	-.092	1.00					
Arithmetic	-.053	.565 ^{xxx}	1.00				
Number	-.042	.136	.268	1.00			
Area	-.058	.142	-.262	-.020	1.00		
Weight	-.131	.300 [*]	.384 ^{***}	.303 [*]	.023	1.00	
Classification	.167	-.206	-.019	.097	-.075	-.131	1.00
Means	112.578	29.022	27.067	7.667	6.378	2.022	4.133
S.Ds.	7.590	8.690	9.910	1.087	2.498	1.815	1.727
Skewedness	.469	-.230	-.004	-.2.958	-1.092	.036	-.556

* P < .05

*** P < .01

Table 4

Intercorrelational matrix, means & S.Ds., of the variables studied using data collected from 1st graders — school B.N = 24.

Variable	Age	School Achievement			Piagetian		Tasks	
		Arabic	Arithmetic	Number	Area	Weight	Classification	Sum & Piagetian
Age	1.00							
Arabic	.491*	1.00						
Arithmetic	.423	.786***	1.00					
Number	.312	.625***	.706***	1.00				
Area	.227	.484*	.505**	.646***	1.00			
Weight	.128	.282	.224	.290	-.212	1.00		
Classification	.411	.724***	.828***	.795***	.580***	.116	1.00	
Sum & Piagetian	.313	.685***	.707***	.933***	.779***	.352*	.784***	1.00
Means	85.571	13.762	14.238	7.286	5.905	1.619	4.714	
S.Ds.	3.854	2.982	3.590	1.648	2.364	1.564	.902	

* P < .05
 ** P < .02
 *** P < .01

Table 5

Percentages and total number of first and third graders who passed or failed the conservation of number, area and weight.

Piagetian Tasks		Conservation of Number		Conservation of Area		Conservation of Weight	
		Passed	Failed	Passed	Failed	Passed	Failed
Grade Level							
First Grade N = 70	Percentage	80%	20%	66%	34%	16%	84%
	Actual Numbers	54	16	44	26	9	61
Third Grade N = 45	Percentage	91%	9%	71%	29%	42%	58%
	Actual Numbers	41	4	30	15	19	26
First&Third Grade Combined N = 115	Percentage	82.61%	17.36%	65.22%	34.78%	24.35%	75.65%
	Actual Number	95	13	74	41	28	107

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العلاقة بين مستوى النمو المعرفي والتحصيل الدراسي عند الاطفال
د . عبد الرحيم صالح
يهتم هذا البحث بدراسة ناحيتين من نظريه بياجيه في النمو المعرفي :
الناحية الاولى تطبيقية وتعنى بدراسة العلاقة بين مستوى النمو المعرفي للطفل كما
تقيسه الاختبارات المشتقة من نظريه بياجيه وبين التحصيل المدرسي لاطفال
الفصلين الاول والثالث في اللغة العربية والحساب كما تقيسها اختبارات معلم
الفصل .

اما الناحية الثانية من هذا البحث فهي فحص لادعاء بان العمليات
المنطقية لاطفال مرحلة العمليات الحسية (٧ - ١١) تظهر في وقت واحد تقريبا، وعلى
سبيل التحديد تفترض نظريه بياجيه ان مفهوم
والاحتفاظ بمفهوم العدد، والاحتفاظ بمفهوم الوزن،
وتظهر عند الطفل في حوالي نفس العمر الزمني، بينما وجدت دراسات اخرى
ان ظهور هذه العمليات المنطقية عند الاطفال يخضع لترتيب زمني معين.
ولفحص هاتين الفرصيتين صممت خمس اختبارات مشتقة من نظرية
بياجيه، وهذه الاختبارات هي :

،الاحتفاظ بمفهوم العدد، الاحتفاظ بمفهوم المساحة، الاحتفاظ بمفهوم الوزن،
والتصنيف المتعدد . وقد اتبع مقياس جاتمان لتصميم هذه
الاختبارات . كما اختيرت عينة عشوائية مؤلفة من ١١٥ طفلة من ١٦ شعبة من
الفصلين الاول والثالث الابتدائية، وسجلت درجات نصف السنة للطالبات في
تحصيلهن الدراسي في اللغة العربية والحساب حسب ما وضعها معلم الفصل.

دلت نتائج هذه الدراسة على ان هناك علاقة ارتباطية معتدلة الى عالية
وموجبة وذات دلالة احصائية بين مستوى الطفلات المعرفي كما تقيسه اختبارات
بياجيه وبين درجاتهم في اللغة العربية والحساب.

اما بالنسبة للقسم الثاني من هذه الدراسة فان النتائج لم تدعم وجهة نظر
بياجيه بوجود ظهور العمليات المنطقية لمرحلة العمليات الحسية في وقت واحد
تقريبا.