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To cite this article: C A Hernández *et al* 2019 *J. Phys.: Conf. Ser.* **1388** 012047

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Multiple intelligences and academic performance in basic education students: An analysis of main components

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Abstract. This research included a sample of students aged between 8 and 16 years, residents of San José de Cúcuta city, Colombia, belonging to socio-economic strata 1 and 2. Multiple intelligences (musical, logical-mathematical, interpersonal, naturalistic, intrapersonal, kinesthetic, linguistic and spatial) were measured according to the proposal by Gardner and school performance as an average of each subject taken during the first two cuts of the school year. The authors applied a principal components analysis with the purpose of characterizing and analyzing these students according to multiple intelligences, academic performance and their relationships. The sample consisted of 60 girls and 61 boys whose average age was 12 years (95% CI: 11.7 – 12.4 years). In the logical-mathematical intelligence was where the students obtained the highest average score, while in musical intelligence the lowest. In the rest of the cognitive capacities they reached similar averages. In relation to the subjects that this group of students studied, the best average grades were in behaviour, religion and physical education and the lowest in English. Through the principal components analysis it was observed that there is no evident association between the types of intelligences and the grades in the school subjects. Girls, in general, achieved better average scores in all subjects compared to their male counterparts ($p < 0.05$). Except for naturalistic intelligence, males show a greater development in the rest of the intelligences, in contrast to the girls who have higher scores in naturalistic intelligence.

1. Introduction

Many have been the efforts that various researchers around the world have made to understand and measure intelligence. Before understanding the concept of multiple intelligences, in order to evaluate the cognitive area of people, experts resorted to tests that used quantitative scales in order to measure the intellectual quotient. This type of tests is not entirely inappropriate, because the qualification in an intelligence test can predict the personal capacity to handle issues related to academic training, however, little predicts about success in the future life [1].

Some researchers do not feel happy with this, they consider that intelligence must be proven with more than brief answers to brief questions. This vision of intelligence does not incorporate the diversity of skills that a person can have to develop certain activities.

Gardner in his work "Structures of the mind. The theory of multiple intelligences" ensures that reason, intelligence, logic and knowledge are not synonymous. In that same work Gardner states that there are at least some intelligences, which are relatively independent of each other, and that individuals and cultures can adapt and combine them in a multiplicity of adaptive ways.



Then, according to what is proposed by this author, intelligences are classified as follows: linguistic, musical, logical, mathematical, spatial, corporal kinesthetic, interpersonal, intrapersonal and naturalistic. This research tries to answer some questions, such as: students with high academic performance, high test scores to measure multiple intelligences? is the age of the learner related to multiple intelligences? Thus, in this study the researchers proposed as a fundamental task, to make a characterization of students belonging to low socioeconomic strata according to multiple intelligences, academic performance and their relationships.

Regarding the above, the academic performance to a sample of students belonging to socio-economic strata 1 and 2; and residing in the neighborhood Juan Atalaya de San José de Cúcuta, Colombia, is characterized according to the multiple intelligences.

2. State of the art

There are numerous studies related to multiple intelligences and academic performance [2] carried out research to measure factors associated with academic performance in university students, a reflection of the quality of public higher education. This author relied on studies conducted in Spain, Colombia, Cuba, Mexico and Costa Rica, with which he concluded that the search for quality implies a comprehensive review of the university that includes studies on the academic performance of students. On the other hand, [3] studied emotional intelligence, personal well-being and academic performance in preadolescents, in which 166 students from the last cycle of elementary school participated. The results showed the existence of significant correlations between well-being and emotional intelligence, as well as between academic performance and well-being, but not between emotional intelligence and academic performance.

In 2004, [4] conducted a study on multiple intelligences in physical education students of the SEK University of Chile. For this, 151 students of the career were evaluated through the multiple intelligences developmental assessment scales (MIDAS). Through the application of this instrument, they found that the development of multiple intelligences is similar in each year of the physical education career, the same occurs between women and men.

In the same order of ideas, [5] carried out a study on multiple intelligences in first-year medical students of a Venezuelan university. In this research, 215, first-year medical students participated, finding that these students achieved very high scores in spatial, corporal, musical and intrapersonal visual intelligence.

In 2009, [6] conducted a study on multiple intelligences, learning styles and performance level. The research involved 40 students of the V semester of the day shift of the academic school of education of the Faculty of Education, found a relationship between the reflective learning style with the theoretical, the pragmatic with the theoretical and the level of performance with the verbal.

On the other hand, in 2009 [7] studied the multiple intelligences and the relationship with the performance in mathematics in students of the fifth year of high school in metropolitan Lima, where 1291 participated. Students of both sexes, as well as, university and pre-university students with a decided by the career to follow, and by dancing painters. The results support the hypothesis that logical-mathematical intelligence correlates more highly with performance in mathematics than with general school performance.

In the year 2016, [8] developed the study of academic performance and self-perception of multiple intelligences and emotional intelligence in first-generation university students, where 252 university-level students from different courses of the Universidad Santo Tomás - La Serena, participated after the first year of University education.

The results reveal weak correlations between academic performance and self-perception of the intelligences, in this way there is no correlation with the other dimensions of emotional intelligence and multiple intelligences [9] studied the relation between emotional intelligence, depression and academic performance in psychology students, where 76 students participated to which the inventory for Beck's depression was applied, the trait meta mood scale. Academic performance was recorded through weighted academic averages. The results indicated a significant negative relationship between emotional

clarity, emotional repair and levels of depression, as well as the non-existence of a significant relationship between emotional intelligence and academic performance.

3. Methodology

The data used were assigned to this study by researchers from the Universidad Francisco de Paula Santander, which came from a sample that consisted of 121 students from whom information was collected on age and gender, as well as measurements of the multiple intelligences described by Gardner in his theory and the average grades in 11 subjects studied during the first two cuts of the 2016 school year. These socioeconomic stratum students 1 and 2 resided in the neighborhood Juan Atalaya of Cúcuta, and their ages were included between 8 and 16 years old.

The eight intelligences proposed by Gardner (musical, logical-mathematical, interpersonal, naturalistic, intrapersonal, kinesthetic, linguistic and spatial) were measured on a quantitative scale between 1 and 10, while the subject grades (Spanish, English, mathematics, social sciences, physical education, natural sciences, artistic education, ethical, religion, technology, behavior) on a scale of 1 to 5.

This is a cross-sectional study, which aims to characterize students through a principal component analysis (PCA) with the purpose of describing the relationships between intelligences and academic performance in school subjects. The statistical packages SPAD 5.6 and SPSS 24, were used.

Using a few linear combinations of the original variables, the PCA explains the variances-covariances structure of these variables, allowing a reduction in the dimensionality of the data and its interpretation. An PCA often reveals relationships of which there was no suspicion and allows interpretations that could not be otherwise [10].

It is a method that summarizes the information contained in the data and provides the analyst with its visual representation [11]. The biplot is a graph that allows to represent simultaneously individuals and variables of an PCA. The closer the vectors that represent two variables are, the higher the correlation between them. Furthermore, if the end of a vector representing a variable is close to the circumference of radius unit, it means that the growth direction of this variable is well defined in the factorial plane in which it is being worked.

Individuals near the center take values close to the mean of the variable and individuals that are distant in the direction of growth of the variable take high values for this variable; the opposite happens in the opposite direction [12].

4. Results

In this section the results of the statistical analyzes are presented.

4.1. Univariate statistical analysis

In Table 1, the students in the sample were between 8 and 16 years old, and the average age was 12.02 years (SD = 1.98). In relation to intelligence scores, the highest average was obtained in mathematical intelligence (8.1) and the lowest in musical intelligence (6.5). Within the academic subjects, the best averages are behavior, religion, physical education and ethics; while English is the lowest average.

Male students show a tendency to present higher average (median) scores than girls in spatial and kinesthetic intelligences; while a lower average score in naturalistic intelligence. In the remaining cognitive abilities, the distribution of scores between girls and boys is similar (Figure 1(a) and Figure 1(b)).

Regarding school subjects, it can be seen in Figure 2(a) and Figure 2(b) that in general, females tend to have better grades in all subjects than boys. When comparing the average score of girls with that of boys, by means of a hypothesis test (t-student test), it was found that the sample provides sufficient evidence ($p < 0.05$) to conclude that there is a significant difference in performance according to gender, with a tendency for girls to reach a higher global average than for men.

Table 1. Descriptive statistics of the variables under study (n=121).

	Min	Max	Average	SD	Subject	Min	Max	Average	SD
Age	8.00	16.00	12.02	1.98	Socials Sc.	1.00	4.90	3.54	0.59
					Physical Ed.	2.50	5.00	4.05	0.57
Intelligence					Natural Sc.	1.00	4.60	3.23	0.79
Naturalistic	1.00	9.50	7.17	2.26	Artistic Ed.	1.00	4.80	3.72	0.56
Musical	2.00	10.00	6.45	1.73	Ethical	3.00	5.00	4.00	0.44
Mathematical	4.00	10.00	8.05	1.27	Religion	3.00	5.00	4.06	0.35
Interpersonal	2.00	10.00	7.88	1.63	Technology	2.00	4.70	3.37	0.59
Kinesthetic	3.00	10.00	7.25	1.63	Spanish	2.00	4.60	3.24	0.84
Linguistic	3.00	10.00	7.81	1.53	English	2.00	4.50	3.19	0.67
Intrapersonal	3.00	10.00	7.36	1.51	Mathematics	1.00	5.00	3.36	0.83
Spatial	3.00	10.00	7.46	1.54	Behavior	3.90	5.00	4.26	0.41

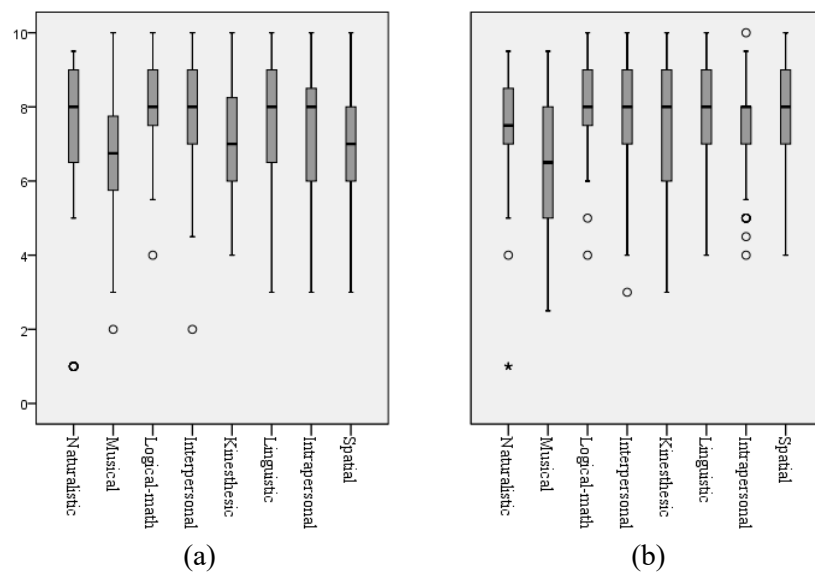


Figure 1. Distribution of intelligence scores according to gender. (a) Female (b) Male.

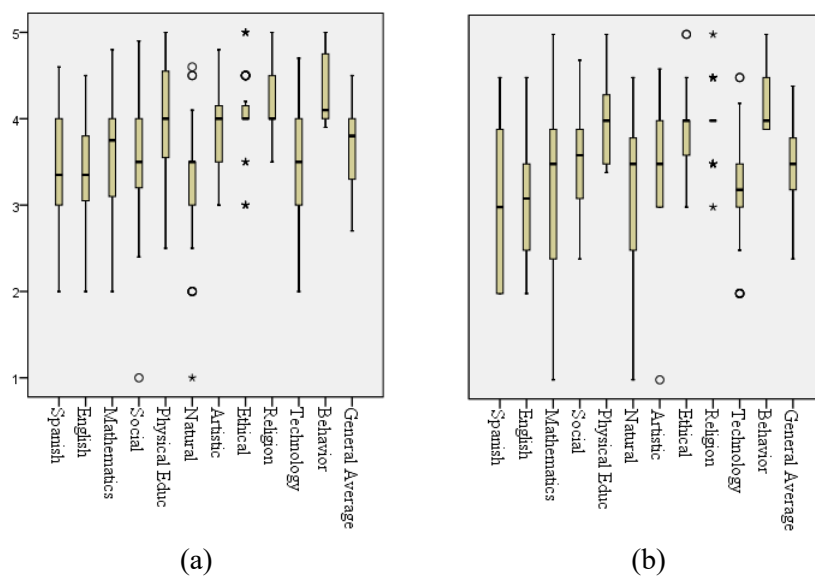


Figure 2. Distribution of the grades of the subjects according to gender. (a) Female (b) Male.

4.2. Principal component analysis

A standard PCA was carried out, in such a way that all the variables (intelligences and subjects) have the same weighting. Table 2 shows the results of the PCA, it is seen that the total variability is explained by 59.4% for the first 4 components. Likewise, the first two components explain 47.7% of the variability. These percentages are not higher due to the number of variables ($p = 21$) and low correlations between the variables studied, however, these components are still very useful for interpreting the factorial close-ups that retain most of the variation.

Additionally, it is observed in Table 2 that in the case of the first factor the general average predominates, and all the subjects show moderate to high correlations. Also, the subjects are very well represented in that axis. The second component is basically dominated by the types of intelligence with a certain predominance of kinesthetic, although the naturalist who is the least correlated (and of the lowest quality of representation) is opposed to all others. The third factor explains 33% of interpersonal intelligence variability, 25% of naturalistic intelligence and, in an opposite way, 24% of spatial intelligence. The fourth axis is correlated with naturalistic and spatial intelligence, as well as with the subjects' ethics and religion. These relationships can be seen graphically in the factorial planes of Figures 3 and 4.

Table 2. Attributes for the interpretation of the first main components: variable-component correlation, (quality of representation), auto-values and percentage of variance explained.

	Principal components							
	Factor 1		Factor 2		Factor 3		Factor 4	
Naturalistic intelligence	-0.04	(0.00)	-0.24	(0.06)	-0.50	(0.25)	0.48	(0.23)
Musical intelligence	0.07	(0.00)	0.70	(0.49)	0.08	(0.01)	-0.04	(0.00)
Logical-mathematical intelligence	0.21	(0.05)	0.46	(0.21)	-0.38	(0.15)	0.19	(0.04)
Interpersonal intelligence	-0.04	(0.00)	0.47	(0.22)	-0.58	(0.33)	-0.01	(0.00)
Kinesthesia intelligence	0.07	(0.00)	0.79	(0.63)	0.04	(0.00)	-0.22	(0.05)
Linguistic intelligence	0.04	(0.00)	0.67	(0.45)	-0.16	(0.03)	0.10	(0.01)
Intrapersonal intelligence	0.17	(0.03)	0.57	(0.32)	0.15	(0.02)	0.24	(0.06)
Space intelligence	-0.07	(0.01)	0.53	(0.28)	0.49	(0.24)	0.37	(0.14)
Spanish	0.82	(0.67)	0.01	(0.00)	-0.21	(0.04)	-0.17	(0.03)
English	0.83	(0.69)	-0.09	(0.01)	0.01	(0.00)	-0.02	(0.00)
Mathematics	0.79	(0.63)	0.01	(0.00)	0.17	(0.03)	0.02	(0.00)
Socials Sciences	0.79	(0.63)	-0.07	(0.00)	0.00	(0.00)	0.22	(0.05)
Physical Education	0.66	(0.43)	0.08	(0.01)	0.02	(0.00)	-0.14	(0.02)
Naturals Sciences	0.58	(0.34)	0.06	(0.00)	0.10	(0.01)	-0.12	(0.02)
Artistic Education	0.71	(0.51)	0.05	(0.00)	0.18	(0.03)	-0.14	(0.02)
Ethics	0.61	(0.38)	-0.21	(0.04)	0.15	(0.02)	0.44	(0.20)
Religion	0.66	(0.43)	-0.14	(0.02)	-0.05	(0.00)	0.41	(0.17)
Technology	0.80	(0.65)	-0.04	(0.00)	-0.12	(0.01)	-0.17	(0.03)
Behavior	0.58	(0.34)	-0.05	(0.00)	-0.18	(0.03)	-0.31	(0.09)
General average	0.99	(0.99)	-0.02	(0.00)	0.02	(0.00)	-0.03	(0.00)
Auto-value	6.77		2.76		1.21		1.15	
Percentage of variance	33.86		13.79		6.05		5.74	
Cumulative Percentage	33.86		47.65		53.70		59.44	

Looking at the graph in Figure 3 and considering the analysis in Table 2, as well as the fact that gender plays the role of supplementary variable, the first component represents students' school performance, which is better between more the projected individuals are located on the right. This shows a tendency for females to achieve better averages in subjects than males. In relation to the second component (vertical axis) that explains the intelligences, there is a slight tendency of the children to show a greater development of the intelligences than the girls, particularly in kinesthetic intelligence and with the exception of the naturalistic intelligence in which the girls are those that seem a slight greater development.

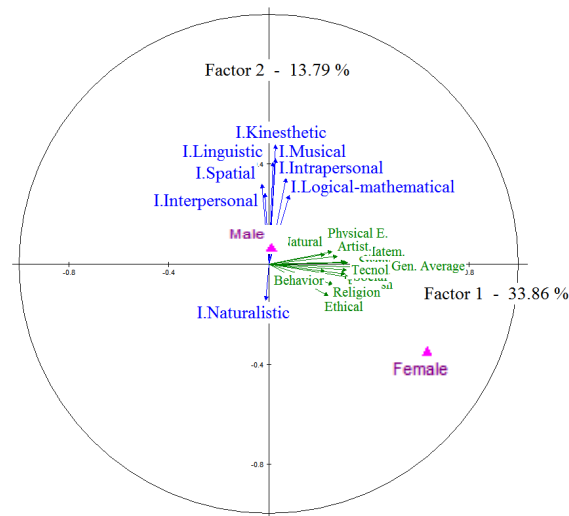


Figure 3. Biplot of the first two main components.

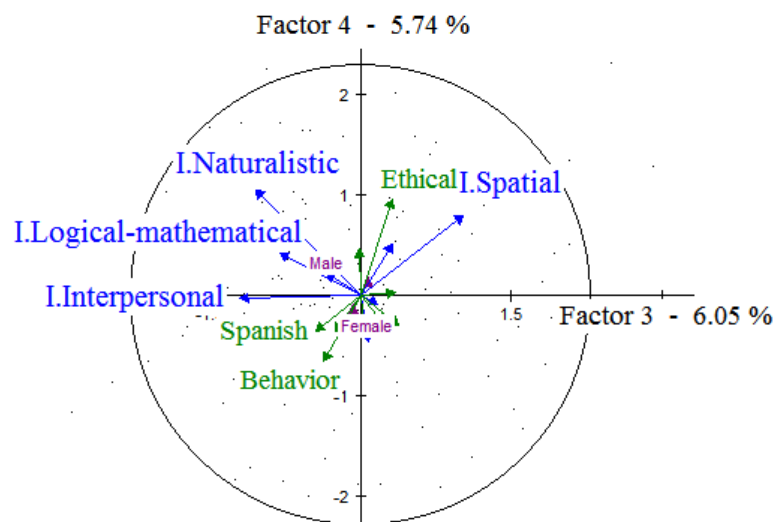


Figure 4. Biplot of the main components 3 and 4.

The third axis reflects a contrast between spatial intelligence, on the one hand, and impersonal and naturalistic intelligences, on the other (see Figure 4). This indicates that a tendency was found for children with greater development in spatial cognitive abilities, at the same time revealing a lower potential in interpersonal and naturalistic intelligence; and vice versa. Men show a slight inclination to present greater potential in spatial intelligence and girls also a greater slight development of naturalistic intelligence. The fourth factor is basically dominated by naturalistic and spatial intelligence, that is, a group of students present a joint development of these cognitive abilities and achieved a good average in the ethical subject.

5. Conclusions

In this statistical study, in the characterization carried out, it was found that the selected students reflect an almost non-existent association between the types of intelligence and performance in their school subjects. Additionally, age was not related to the intelligences either. The students of this research presented higher school performance in the subjects of behavior, religion, physical education and ethics, which are probably among those that require less cognitive effort.

On the other hand, it was found that girls' school performance is significantly higher than that of boys ($p < 0.05$). The subjects that have more weight in the conformation of the average of the students in the sample are, English, Spanish, technology, mathematics and social sciences. In a very mild way, girls tend to have a greater potential in naturalistic intelligence. While the males show slightly more development in the rest of the intelligences and in a slightly more predominant way in the spatial intelligence and kinesthetic intelligence.

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