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CHARACTERIZATION OF STUDENT PERFORMANCE IN THE CATEGORIES AND CONTENTS MEASURED IN THE AREA OF MATHEMATICS

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Abstract
This research is implemented at the Policarpa Salavarrieta educational institution in 11th grade students with a sample of 5 students determined by the method of obtaining the sample size of the 3x2 factorial design and chosen randomly among all the students that make up grade 11 and with which we seek to know the relationship that may exist between the categories and contents evaluated by the ICFES 11th test in mathematics, through applied research, with a transversal design and quantitative approach. The data collection instrument was a questionnaire with ICFES 11th test-type questions. A 3×2 factorial experimental design was applied, which was carried out through an analysis of variance (ANOVA) with the information obtained. A hypothesis test was carried out in which the calculated statistics from the ANOVA table and the tabulated statistics of the Fisher F distribution were compared, with the objective of evaluating the effect of dependence between the variables involved in this study.

Keywords: Factorial Design, ICFES 11° Tests, Categories, Contents, Hypothesis Test.

1. Introduction

Learning is a factor present in all stages of life and is of great relevance to the way we learn. Currently, there is an infinite amount of research on this topic. In addition, it is equally important the adequate way to verify what is learned (evaluation), which is why in countries like Colombia, national standardized tests are being implemented to measure the knowledge acquired by students at all levels of education, as is the case of the test saber 11°, conducted by the Colombian Institute for the Evaluation of Education (ICFES), which is the entity responsible for evaluating, in Colombia, at all levels of education, providing information on the aspects that affect the quality of education to contribute to the improvement of education (ICFES, s. f.).

The results obtained by this test are not encouraging, because the students showed many difficulties in several of the evaluated areas, especially in this study that was conducted in the educational institution Policarpa Salavarrieta in Sincelejo-Sucre, in which we wanted to check to what extent the performance of students in grade 11, in the ICFES 11° test in the area of mathematics, through the

implementation of a completely randomized factorial design, in order to anticipate the possible results that students could obtain in the test and to be able to provide the institution with information that could serve as input when making decisions regarding the improvement of the deficiencies found.
Several studies were taken into account that allowed basing and guiding this study, such as those conducted by Figueroa & Vargas (2017), Alarcón (2022), and Bolaños (2019); in others, the results indicate that academic performance influences the results obtained in the saber 11° tests and from the identification of the different aspects that are part of this process, improvement plans can be implemented, given that the existence of a standardized test directly affects the way mathematics is taught, the efforts are directed to what is evaluated.
The objective of this paper is to determine whether the performance of students measured in the score obtained in the ICFES 11° tests in the area of mathematics depends on the categories Geometry, Statistics, and Algebra and Calculus, and the generic and non-generic contents.

2. Theoretical Framework

2.1 ICFES 11° Tests

For all secondary education institutions, it is important to measure the learning that students present at the end of their basic education stage through a test that the Colombian Institute for the Promotion of Higher Education (ICFES) is relevant for measuring knowledge, skills, and competencies. Therefore, it is necessary to understand what this test consists of. According to Medina and Salazar (2015), the ICFES 11° tests were applied by the Ministry of National Education to students in the last grade of all public and private establishments in the country in order to check the degree of development of the competencies of each of these and as a requirement for admission to higher education.
The objectives of the ICFES 11º test were as follows:
- To verify the degree of development of the competencies of students who are about to finish the eleventh grade of secondary education.
- To provide students with elements for self-evaluation and development of their life projects.
- To provide educational institutions with pertinent information on the competencies of those aspiring to enter higher education programs, as well as those who are admitted, to serve as a basis for the design of academic leveling programs and prevention of desertion at this level.
- Monitoring the quality of education in the country's educational institutions based on the basic competency standards and quality benchmarks issued by the Ministry of National Education.
- To provide information for the establishment of value-added indicators for both secondary and higher education.
- Serve as a source of information for the construction of education quality indicators as well as for the inspection and surveillance of public education services.
- To provide information to educational establishments that offer secondary education for the exercise of self-evaluation and consolidation or reorientation of their pedagogical practices.
- To offer information that serves as a strategic reference for the establishment of national, territorial, and institutional educational policies.

2.2 Types of Questions

The exam consists of multiple-choice questions with a single answer comprising a statement (which presents a situation, figure, text, etc.), an evaluation task (what the student is asked to perform), and several answer options, of which only one responds to the task posed.

2.3 Competencies

The concept of competence is not unique; there are several authors who give a definition of this topic and discuss its importance not only in mathematics but also in all areas of knowledge. Medina and Salazar (2015) mention that “They refer to the processes that the student must perform to solve what he/she poses, which can also be considered as tools that dispose the subject to propose solutions to some problem”.

2.4 Mathematical competencies

Speaking specifically of mathematical competencies, Acevedo and García (2000) state that the notion of competence "is associated with what people do with mathematical objects, relations, structures, procedures, and forms of reasoning; that is, it represents the personal construction, in the sense of the use of knowledge, what the student does with what he/she knows.

In addition, Mogens (2002) mentioned that mathematical competence refers to the ability to understand, judge, do, and use mathematics in a variety of contexts in intra- and extra-mathematical situations in which mathematics plays or could play an important role.

2.5 Mathematics Competencies Evaluated by the ICFES 11° Test

According to the reference framework for evaluation, ICFES (2019), the ICFES 11° tests evaluate 3 competencies that are in accordance with the requirements of the basic competency standards, which are the following: interpretation and representation, formulation and execution, and argumentation.

2.6 Curricular Mathematical Contents

According to the ICFES Orientation Guide (2022-1), mathematical content is classified into three categories, depending on the situation posed by the problem. These are statistics, geometry, algebra, and calculus.

Each of the above categories was subdivided according to the content type:

Generic: Corresponds to the fundamental elements of mathematics necessary for every citizen to interact critically in today's society.

Non-generic: Corresponds to contents that are considered specific or specific to the mathematical task and are learned in the school stage.

3. Methodology

3.1 Population under study

The population under study was students of grade 11 belonging to the Policarpa Salavarrieta Educational Institution.

3.2 Sample

Simple random sampling will be applied to select the sample of 11th grade students that will be part of the study; there will be five students from the different 11th grade groups in the institution. The samples were calculated using the following formula:

$$\phi^2 = \frac{nbD^2}{2a\sigma^2} \qquad \text{Ec. 1}$$

Where:
a: number of categories(3 levels)
b: number of contents (2 levels)
σ^2: represents the variance (historical variance of the results in the mathematical test).
D: Distance to determine the significant difference between the two aspects involved (D=20).

With the help of the characteristic operating curves, a significance of $\alpha = 0.05$, a power of $1-\beta = 0.98$, and the following sample size was obtained:

$$\phi^2 = \frac{n(2)(20)^2}{2(3)(103{,}713094)} = 1.28n$$

Table 1. Obtaining the Sample Size

N	ϕ^2	ϕ	a(n-1)	β	(1-β)
3	3.86	1.96	6	0.38	0.62
4	5.12	2.26	9	0.13	0.87
5	6.4	2.53	12	0.05	0.95

Table 1 presents the optimal sample size for this study.
Sample size: $n = 5$
With $\alpha = 0.05; \beta = 0.05; (1 - \beta) = 0.95$

This sample size was chosen because it provided a significance of 95%, which indicates that the research will be feasible.

3.3 Data Collection Technique

Questionnaires were designed with ICFES 11° test-type questions, in which the categories and content in the area of mathematics were evaluated. These questionnaires were administered to a sample of 11th grade students chosen for this purpose.

3.4 Treatment of the information

To collect the necessary information, a questionnaire was designed with ICFES 11° test type questions, where mathematical competencies were evaluated with questions distributed in the two types of categories that the test evaluates; one related to the concept of mathematical literacy proposed by PISA, called generic that is contextualized in ICFES (2015), which corresponds to the dynamization of competencies with the minimum of mathematical tools that every citizen should have at their disposal to face diverse situations of life.
Another non-generic call is oriented to the evaluation of specific mathematical knowledge developed in the basic and middle school stages in three components: numerical-variational, geometric-metric, and random (1).
As the maximum score of the mathematics test is 100 points, each question will have an equal evaluation, such that the sum of these values adds up to 100 points. Once the information has been collected, we apply the most appropriate experimental design for data analysis.
Subsequently, using the results of the analysis of variance performed, we will identify whether student performance depends on the category and content evaluated. For this purpose, we define three variables X, Y, and Z such that:
Variables X and Y are the independent and qualitative variables, which in this study represent the category and content evaluated, respectively.
Variable Z is a dependent and quantitative variable, which in this study represents the score recorded for each category and content. These scores range from 0 to 100 points.

4. Hypothesis Testing and Results

4.1 Descriptive Statistics

The following is a descriptive analysis of the data obtained from the implementation of the ICFES 11° test questionnaire in our sample of students.

Table 2. Descriptive Analysis of the Data

Contents	Categories	Minimum	Maximum	Average	Mode	Range	Variance	Standard Dev.
Generic	Statistics	33.3	100	66.6	66.6	66.7	555.56	23.57
	Geometry	0	66.6	46.6	66.6	66.6	888.89	29.81
	Alg. y Cal.	0	66.6	46.6	66.6	66.6	888.89	29.81
Non-generic	Statistics	0	66.6	26.6	0 y 33.3	66.6	777.78	27.89
	Geometry	0	66.6	20.0	0.0	66.6	888.89	29.81
	Alg y Cal.	0	33.3	13.3	0.0	33.3	333.33	8.26

Table 2 shows the descriptive statistics of the data obtained from the questionnaire applied to 11th grade students of the Policarpa Salavarrieta educational institution.

4.2 Analysis of variance

The analysis of variance or ANOVA table was carried out considering the data obtained in the application of the instrument (question type Saber 11). The analysis was performed at a significance level of $\alpha = 0.05$.

Table 3. Results of the 3x2 analysis of variance

ANOVA	SS	G.L.	CM	Fo	F(α,a-1,ab(n-1))	P- value
Categories	1555.555	2	777.777	1.077	3.4028	0.3565
Content	8333.333	1	8333.333	11.538	4.2596	0.0023
Cat-Cont Interaction	222.222	2	111.111	0.1538	3.4028	0.8582
ERROR	17333.333	24	722.222			
TOTAL	27444.444	29				

Table 3 shows the results of the analysis of variance for hypothesis testing.
According to the results of the ANOVA table and with respect to the P-values, the following can be observed:

4.2.1 Factor A Hypothesis Test

Since the P-value associated with the Math Category factor is greater than the significance $\alpha = 0.05$, that is, P-value =0.35653989 > 0.05, the null hypothesis is described as:
HO: The score does not depend on the mathematical category evaluated; is accepted, which means that the score obtained by the student does not depend on the mathematical category evaluated.

4.2.2 Factor B Hypothesis Test

Since the P-value associated with the factor Mathematical Content is less than the significance $\alpha = 0.05$, that is P - Value = 0.00237603 ≤ 0.05, the null hypothesis is described as:
Ho: The score does not depend on the evaluated content and is rejected, indicating that the student's score depends on the evaluated mathematical content.

4.2.3 Hypothesis Test of the Interaction of the AB Factors

Since the P-value associated with the interaction category content is greater than the significance $\alpha = 0.05$, that is, P-value = 0.85824274 > 0.05, the null hypothesis described as: there is no interaction between the evaluated mathematical category and the content, is accepted, indicating that there is no interaction between the factors category and mathematical content. Figure 1 shows the interaction between the two types of content with respect to categories.

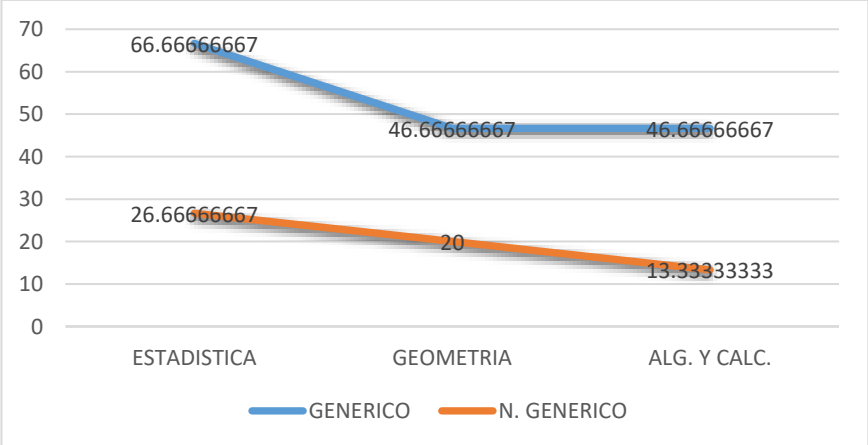

Figure 1. Contents-Categories Interaction Graph

From the previous graph, we can extract the following information.
- It is observed that between the two lines that represent the mathematical contents with respect to the categories, there is no intersection, which indicates that there is no interaction between the factors established in this study, as evidenced by the hypothesis test of the interaction of the two factors. This means that the categories evaluated by the icfes in the ICFES 11° tests in mathematics do not exert any influence on the results obtained in the two mathematical contents evaluated.
- It is also evident that there is a notable difference between the two types of content with respect to the categories, where students have higher results in the generic content in the three categories, and statistics is the category where the highest score is obtained for both contents.
- The results show that the statistics category has the highest average score in the generic CONTENT, 66.666, on a scale of 0 to 100 points. However, algebra and calculus obtained the lowest score of 13.333 on a scale of 0–100 points for non-generic content.
- In the graph, it can be seen that in the three categories present in each of the contents, it is in geometry where the average score is the closest in comparison to the other corresponding categories.
- Likewise, of the three categories evaluated by the Saber 11 test in mathematics, it is algebra and calculus, where the lowest score is obtained for both evaluated contents.

5. Conclusions

In our research, we found that the score will depend exclusively on the type of mathematical content in which the Saber 11 test is being evaluated; that is, if it belongs to the generic content (mathematics that every individual should handle) or the non-generic content, which is the mathematics that is addressed throughout the course of secondary education, satisfactory or deficient results will be obtained.

Students will perform better in generic content than in non-generic content, regardless of the category being assessed. This may be because students have a greater mastery of the basic mathematics they have learned throughout their lives and not the mathematics taught in school; the latter has a greater capacity and the development of competencies to handle it.

According to the results obtained, it was evident that students will present greater difficulties in the non-generic content in the category of algebra and calculus, which makes sense, since eventually, the main learning difficulties of students in mathematics belong to this category.

It was also evidenced that when students took the mathematics test, there were greater strengths in the generic content in the statistics category than in the other categories that were also evaluated by the ICFES.

6. Recommendations

It is recommended to the educational institution Policarpa Salavarrieta to design an improvement plan for the non-generic contents evaluated by ICFES in the state test to make up for the difficulties or deficiencies presented by the students in the results in the area of mathematics, without leaving aside or neglecting the generic content.

To use the present work as a basis for future research projects, we focused on the implementation of strategies to solve the problems that students present in the Saber 11 test in the area of mathematics.

It is suggested to carry out similar research projects in other areas of knowledge, where difficulties are also being presented both nationally and internationally in these standardized tests, in order to form integral students capable of responding to the needs and challenges that the current reality requires.

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