STUDENTS' LEARNING OF REPRESENTATION IN TABLES IN THE EARLY YEARS OF ELEMENTARY SCHOOL

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We investigated how table teaching and learning can be developed in the elementary school through an experimental study with 70 students from the second and fifth grades. The tasks addressed interpreting and building single and two-way tables. In the pre-test, second grade students could find frequencies in tables, although they had trouble using data in tables to make decisions or to evaluate conclusions. After the intervention, they learned to establish relationships between data, no longer justifying them based on life experiences. The second-grade students started building simple tables and fifth grade students built two-way tables. Thus, we highlight the possibility of learning the topic as long as teaching addresses activities that lead students to reflect on real contexts to confront conclusions and make decisions.

INTRODUCTION

Statistical education is essential to form citizens capable of understanding and critically analyzing information for decision making. Statistics learning must begin in the first years of schooling, because it allows for more complete social and scientific development.

Tables are essential representations of statistical data. We use tables to organize data, to reflect on data, and to make decisions from data. Therefore, in this study, we are interested in discussing the teaching and learning of tables in the early years of elementary school as a learning object.

Such concern is justified because, in the current context, we cannot ignore the use of tables in different areas of human life. For example, tables are included in scientific research results, textbook tasks, journalistic texts published in newspapers and magazines, and other everyday activities. Gabucio, Martí, Enfedaque, Gilabert, and Konstantinidou (2010) state that tables are ordinary daily life devices. Hence, as a historical and functional result in the scope of knowledge creation and expansion to people's lives, tables become part of basic education teaching plans.

Evangelista, Guimarães, and Oliveira (2021) show that tasks with tables are proposed in textbooks as tools, that is, to focus on other content and not as an object of study. We believe this has been a mistake because students find it hard to interpret and build tables, according to Guimarães, Evangelista, and Oliveira (2021).

As stated by Martí, Sedano, and La Cerda (2010), tables should be an object of teaching. We agree with the authors that teachers must seek to know students' difficulties and propose different tasks so that students can learn about tables to consider their elements and their relationships, differentiate rows and columns and relationships between them, and know descriptors and cells in order to determine relationships over all the information, come to conclusions about the data presented, and understand how data fit into the table structure. To this effect, it is necessary to explicitly address the variables represented in the tables and the different types of tables. Estrella (2014) suggests that teachers should promote data classification tasks and develop students' skills to tabulate data, verify results, share interpretations and misunderstandings, and write considerations.

We therefore believe we should teach tables directly. We can do this through carefully designed activities using different variables and contexts in which students pay attention to the construction and visual structure of tables, and where students see how they can use that structure to find patterns in the data.

So, we seek to investigate how table teaching and learning can be developed in the early years of elementary school, involving second- and fifth-grade students.

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METHODS

From an experimental approach, this study involved 70 Brazilian elementary school second and fifth graders (7–8 years old and 10–11 years old, respectively), with two classes from each grade. Data collection (individual pre-test, teaching intervention, and individual post-test) included tasks of interpretation and construction of single and two-way tables. The interpretation questions in both pre-tests and post-tests required: (a) locating a frequency cell; (b) making a decision based on the data, with justification; and (c) analyzing correct and incorrect conclusions, with justification. The students were encouraged to analyze the data in the tables to arrive at an answer. See Figure 1 for an example of an interpretation question.

1- According to the population census by IBGE in 2010, the Brazilian population is living longer. In the table below, we have the number of people over 100 years of age in some cities in Pernambuco.

Population over 100 years of age in some cities in Pernambuco

Cities	Population over 100 years old
Garanhuns	34
Vitória de Santo Antão	30
Camaragibe	26
São Lourenço da Mata	15
Igarassu	22

Source: https://censo2010.ibge.gov.br/sinopse/index.php?dados=12

a) How many people in Camaragibe are over 100 years old?

b) An elderly couple over 100 years old is choosing a city to live in. From the table above, which city should the couple choose? Why?

c) From the table, I can say that in São Lourenço da Mata, people are more likely to live over 100 years? Why?

Figure 1. Post-test question to interpret a simple table with a nominal qualitative variable

As for the construction questions, one required building a single table from the classification of 13 elements, and the other required building a two-way table from a database with two variables. (See Figure 2 for an example of a construction question.)

In this database we have some types of materials that can be recyclable or not. Build a table by systematizing this information.

Material	PAPER	METAL	PLASTIC	NON RECYCLABLE	RECYCLABLE
Pet bottles			X		X
Cans		X			X
Pizza box	X				X
Toilet paper	X			X	
Cardstock paper	X				X
Bottle caps		X			X
Pot handle			X	X	
Newspaper and magazine	X				X
PVC pipe			X		X
Adhesive label	X			X	
Steel sponge		X		X	
Ice cream pot			X		X
Plastic bags			X		X

Figure 2. Post-test question to build a two-way table

We classified students' answers as correct or incorrect using the criteria/objectives exposed in the questions. The student's score on the complete assessment could vary between 0 and 18 points, depending on the number of correct answers obtained. The first four questions of the test involved interpreting data in tables, and one point was assigned for each correct item (a, b, and c). The last two questions explored students' abilities to construct tables (single or two-way tables). In question 5, one point was assigned for a classification that met the criteria of exclusivity and exhaustiveness, one point for a constructed table that represented the systematized data from the classification performed previously, and one point for representing the elements of the table (title, descriptor, and classes). In question 6, one point was assigned per table that displayed one of the variables or two points per table with two variables. Another point was assigned for representing the elements of the table (title, descriptor, and classes).

The teaching intervention took place in two sessions (of approximately 2 hours each session) on different days. On the first day, the classes worked with two activities to build simple tables from raw data and one activity to interpret a two-way table. On the second day, the students dealt with databases to support the construction and interpretation of two-way tables. In the intervention, students were asked to solve one activity at a time. During the intervention, the researcher started the activity, seeking to assess students' prior knowledge about the topic and the concepts explored. After that, students engaged in the activity. Then, the researcher gathered students together to discuss the activity and to perform the collective correction/systematization of the activity, seeking to stimulate discussions and reflections on the part of the students about the answers given and the concepts explored in the activity.

The activities sought to promote learning by leading students to reflect, systematically and intentionally, on the fundamental elements that structure a table and a table’s function in the communication of data on people’s physical and social lives. In carrying out the interpretation activities, we wanted students to identify the values of the cells, but, mainly, we wanted them to extract ideas about data patterns to analyze the information and subsequently make decisions. In the construction activities, we sought to draw students’ attention to the criteria to classify the elements, the relationship between the variables, and the type of table built to represent the data (single table and two-way table).

RESULTS

For the pre and post-tests, we considered a maximum score of 18 points, ranging from 0 to 3 points for each question, evaluating different important aspects for each (Table 1).

Table 1. Average of correct answers by the groups, by school grade and stage

Student group	Pre-test	Post-test
Second grade ($N = 35$)	6.20	11.86
Fifth grade ($N = 35$)	8.29	14.91

Using a matched pairs *t*-test, the mean scores differed significantly between the pre-test and post-test for each group, that is, for second grade [t (34) = 14,885; $p \leq .000$] and for fifth grade [t (34) = 17,068; $p \leq .000$]. In this way, we found that the students who participated in the sequence of activities for table learning improved their performance in solving the tasks after the intervention. In the post-test, second graders had a higher average score on their post-test (11.86) than the fifth graders, who have three more years of schooling, had on their pre-test (8.29), which may be an indicator of the possibility of students learning much earlier than what has been proposed and developed in schools. This shows that younger children can understand the world based on this type of representation and as they advance in their schooling, they expand this understanding.

Our results showed that all groups performed significantly better on all post-test questions, regardless of the type of skill explored in them (interpreting or constructing). For interpretation tasks, second graders’ scores improved from 40.25% (pre-test) to 70.75% (post-test), and fifth graders’ scores improved from 51.42% (pre-test) to 79.75% (post-test). For construction tasks, second graders’ scores improved from 22.83% (pre-test) to 56.17% (post-test), and fifth graders’ scores improved from 35.17% (pre-test) to 89% (post-test).

We believe that these results are very important, considering that after only two meetings promoting intentional and systematic sequences of activities for table learning, children in different levels of schooling (at the beginning and end of elementary school) and from different public schools could advance in their understanding of table representations, regardless of the type of table and variable.

Figure 1 presents a post-test task for interpreting a simple table. We can see that part "a" involves identifying a value, part "b" involves making a decision based on the data presented, and part "c" involves evaluating an incorrect conclusion.

Second-grade students knew how to locate frequencies presented in tables. However, on the pre-test, they primarily used arguments that focused on personal wishes or life experiences, or they chose any of the given data, which did not meet the requested situations. Many justifications tended to be of the form: "*Because I like it"; "it's good, my team"; "it is what I chose"; "yes, because the footballers like to get into a fight."* Essentially, they ignored the data in the tables or the relationships between them. After the intervention, they began to seek coherent evidence that supported their answers using the data in the tables. Thus, when asked, for example, in which city an elderly couple over 100 years old could choose to live, the student chose the city of "*Garanhuns, because there are more people of that age,"* that is, they used information from the table. In another situation, when asked about a mistaken conclusion about the higher possibility of living more than 100 in the city of São Lourenço da Mata, another student observed that the statement was wrong and justified: "*No, because there are only 15 people who are 100 years old and the others (cities) are 22, 26, 30, 34."* In São Lourenço da Mata, there were fewer residents over 100 years of age compared to the other cities. In this way, both children confronted the data in the table with the situations presented and used it to justify their answers.

As for the construction tasks, in the pre-test, we found many productions like the one in Figure 3, in which there is no identification of the classes/quantities. (pre-test) Thus, we were not able to know to whom the quantities were actually referring. In the post-test, most students, in an equivalent task, built simple tables from raw data that needed first to be classified. In Figure 4, we have the representation of a simple table built with the representation of title, descriptors, and classes

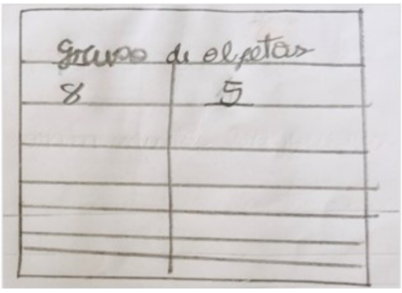

Figure 3. Table without the identification of classes/quantities (pre-test) [Title is "group of objects"]

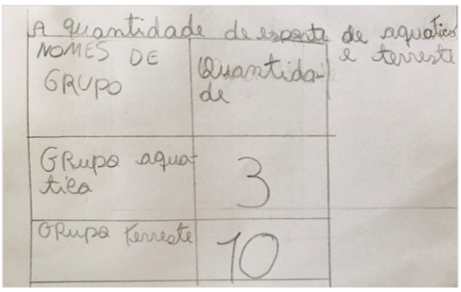

Figure 4. Table built with the representation of title, descriptors, and classes (post-test)
[Variables are amount of water and land sports]

In the pre-test, students from both grades were able to build only a simple table from a database even though the data required a two-way table. Building two-way tables is more difficult for students, as reported in the literature (Guimarães et al., 2021; Martí et al., 2010). The difficulty occurs due to the lack of spatial logic knowledge of two-way tables.

In the post-test, unfortunately, the activities proposed in the intervention during the two days were not enough for the second graders to learn how to construct two-way tables. They chose only one of the variables to construct their tables, although they presented them correctly (Figure 5). On the other hand, we identified that 65.7% of the fifth-grade students could build two-way tables. Thus, for this school grade, the two-day sequence of activities for table learning was effective for those students to understand the spatial logic of two-way tables. In the example of Figure 6 we have a correctly constructed two-way table in which the student places the descriptors of the two variables and the specific elements of this representation (title, descriptor name, and classes). In the production, it is possible to observe how the student was careful to organize the data by material groups that can be recyclable and non-recyclable, systematizing and representing within the rectangular structure of the table.

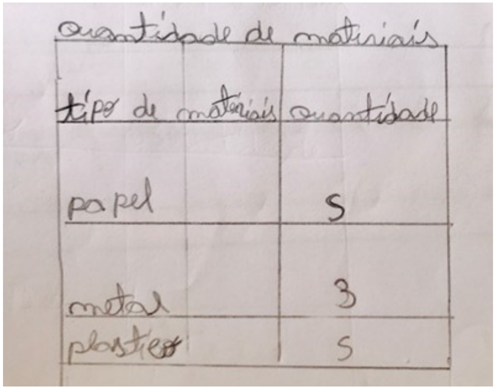

Figure 5. Second-grader’s table from the pre-test [Title is “quantity of materials”; column headers are “type of material” (paper, metal, plastic) and “quantity”]

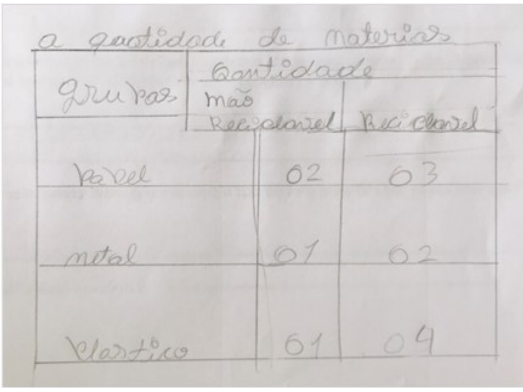

Figure 6. Two-way table built with the elements title, descriptor name, and classes from the post-test [Title is “Quantity of materials”; groups are classified by the quantity of non-recyclable and recyclable materials]

These results show that the participants stopped using other representations or partially constructed tables and started producing simple and two-way tables, taking care to place all the elements, which is significant progress compared to the performances on the pre-test.

CONCLUSIONS

We investigated how table teaching and learning can be developed in the early years of elementary school. We found evidence that it is feasible to teach tables as a mathematical object in the early years of elementary school. The students who participated in the intervention we developed and implemented with tasks with tables began to reflect critically on their functionality and importance in the communication and analysis of information with actual data, presenting arguments based on the data of the representations. Students also built higher quality tables from raw data and databases, considering the type of tables and fundamental elements. Thus, we argue that understanding the table representation can occur through a teacher's intentional work, leading students to discussions and reflections on the functionality and importance of this representation to communicate and analyze data. The knowledge about tables needs to be considered an object of teaching and learning and not just used as a tool to teach other contents.

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