

# Images, Scores, Conceptions, and Perceptions: Basic Sanitation in the view of Middle School Students

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## ABSTRACT

This article aims to investigate the conceptions and perceptions of students from the 8th and 9th year of the middle school regarding the four scopes of basic sanitation articulated with the themes addressed in the curriculum each year. Forty-nine students from a state school in Estância Velha/RS participated with activities involving questionnaires application, photovoice and image evaluations from the perspective of Mixed Method Research. Qualitative data were from observations present in the logbook and answers to the open-ended questions of the questionnaires. The quantitative are the scores attributed by the students analysed with the tools of descriptive statistics and with the non-parametric test of Kruskal-Wallis. The results showed that the use of images and the attribution of scores articulated with qualitative data were fruitful to understand the perceptions and conceptions of the students. It was evidenced that sewage and water supply were the most frequently remembered elements regarding basic sanitation, followed by solid waste. However, drainage was not remembered as a component of basic sanitation, requiring the construction of integrative educational practices from the four scopes seeking to expand students' perceptions and conceptions about basic sanitation and its relevance in contemporaneity.

**Keywords:** Environmental Education; Middle School; images; Mixed Methods Research; basic sanitation.

## Imagens, Escores, Concepções e Percepções: o Saneamento Básico no Olhar de Estudantes de Ensino Fundamental

### RESUMO

O presente artigo tem como objetivo investigar as concepções e as percepções de estudantes do 8º e do 9º ano do Ensino Fundamental a respeito dos quatro âmbitos do saneamento básico de forma articulada com as temáticas abordadas no currículo de cada ano. Participaram 49 estudantes de uma escola estadual de Estância Velha/RS com atividades envolvendo aplicação de questionários, *photovoice* e avaliações de imagens sob a perspectiva da Pesquisa com Métodos Mistos. Os dados qualitativos decorrem das observações presentes no diário de bordo e das respostas às questões abertas dos questionários. Os quantitativos são os escores atribuídos pelos estudantes analisados

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com as ferramentas da Estatística Descritiva e com o teste não-paramétrico de Kruskal-Wallis. Os resultados demonstraram que a utilização de imagens e a atribuição de escores articuladas com os dados qualitativos foram profícuos para compreender as percepções e as concepções dos estudantes. Ficou evidenciado que o esgotamento sanitário e o abastecimento de água foram os elementos mais frequentemente lembrados a respeito do saneamento básico, seguidos dos resíduos sólidos. No entanto, a drenagem é reduzidamente lembrada como um componente do saneamento básico, demandando a construção de práticas educativas integradoras dos quatro âmbitos buscando ampliar as percepções e concepções dos estudantes a respeito do saneamento básico e sua relevância na contemporaneidade.

**Palavras-chave:** Educação Ambiental; Ensino Fundamental; imagens; Métodos Mistos; saneamento básico.

## INTRODUCTION

Urbanisation processes occurred/occur in a disorderly manner in many regions of Brazil, with profound repercussions on basic sanitation. Informality in the construction of housing and precariousness in the infrastructure of sanitation services is associated with habitation expansion in improper areas, generating environments of greater unhealthiness and vulnerability (Teixeira, Oliveira & Viali, 2014 ). These areas are usually located near the water springs or are seasonally affected by the natural course of rivers. Besides, in many regions, garbage and sewage are launched along the bed of rivers and streams without any treatment, causing risks to the health of the population and danger to the other species that inhabit the places (Dal-Farra, Oliveira & Dal-Farra, 2015; Who, 2018).

The basic sanitation theme encompasses a broad context in the urban scenario and demands an interdisciplinary conception focused on the development of knowledge, values, and social practices (Brazil, 2013; Dal-Farra, Oliveira & Dal-Farra, 2015). Therefore, it is necessary a constant rethinking pursuing innovative actions that contribute to the historical processes that characterize/characterized the community over the years and the school is a place of excellence for the learning of these issues, forming citizens aware of their rights and duties in the community (Iervolino & Pelicioni, 2005, Dal-Farra, Costa, Proença, Veloso & Assunção, 2015).

The formal education system needs to contemplate the construction and application of educational practices that can contribute to students and the surrounding community to understand the issues inherent to basic sanitation in its complexity, because of the interrelations between the areas that make up this relevant scope of urban life.

Due to these concerns, the present study proposes to investigate the conceptions and perceptions of students from the 8th and 9th years of middle school on the four areas of basic sanitation in an articulated way with the themes addressed in the curriculum of each year seeking to build subsidies so that basic education teachers can address this crucial theme of contemporary life in their educational practices.

## THEORETICAL BASES

### Basic sanitation and educational practices

The World Health Organization defines sanitation as access to and the use of facilities and services for the safe disposal of urine and human faeces. A safe system, in this perspective, is designed to separate human waste from contact with people at all stages of the service chain, from capture, through transportation, treatment, and reaching the final elimination of these contents in the appropriate place (WHO, 2018).

Basic sanitation can also be understood as the set of measures aimed at preserving or modifying environmental conditions in order to prevent diseases, promote health, improve the quality of life of the population and contribute to the productivity of the (Instituto Trata Brasil, 2012).

The expression “basic sanitation” was used by Brazilian legislation due to the essentiality of services that encompass this crucial constituent element of contemporary urban life. Concerning legislation, the recommended concept comprises the set of services, infrastructure and operational installations for water supply, sewage, rainwater drainage, and urban cleaning and solid waste management, as presented in Law 11.445/2007 (Brazil, 2007):

(a) drinking water supply: consisting of the activities, infrastructure, and facilities necessary for the public supply of drinking water, from capture to building connections and their measuring instruments;

b) sanitary sewage: consisting of activities, infrastructure and operational facilities for the proper collection, transport, treatment and final disposal of sewage, from building connections to their final launch into the environment;

c) urban cleaning and solid waste management: the set of activities, infrastructure and operational facilities for collection, transportation, transshipment, treatment and final destination of household waste and waste originating from sweeping and cleaning of patios and roads public agencies;

d) drainage and management of rainwater, cleaning and preventive supervision of the respective urban networks: the set of activities, infrastructure and operational installations of urban drainage of rainwater, transport, detention or retention for the cushioning of flood flows, treatment and final disposal of rainwater drained in urban areas (Brazil, 2007).

The law mentioned above represents the regulatory framework for Brazil, establishing the National Guidelines for the Federal Policy about Basic Sanitation and the mandatory preparation of the Municipal Basic Sanitation Plan. Another advance was Law No. 12,305 (Brazil, 2010a) that deals with the National Solid Waste Policy and the guidelines of its integrated management. Concerning water resources, Law 9,433

(Brazil, 1997) establishes the National Water Resources Policy focused on shared and decentralised management of these services in the country.

Despite today's significant technological development with regard to the possibilities of construction of works focused on basic sanitation, the country lacks actions that can contribute to the planning, infrastructure and availability of services that can improve the quality of life of the population (Ayach, Guimarães, Cappi & Ayach, 2012; Dal-Farra, Oliveira & Dal-Farra, 2015).

At this juncture, the problems mainly affect the low-income population, whose greater vulnerability and exposure to unhealthy environments resulting from precariousness or lack of basic sanitation services pose a threat to health and well-being (Brazil, 2007, Heller, 1998). Thus, it is necessary to promote access to these services as a preventive measure essential to the quality of life of the population (Brazil, 2009).

According to data from the National Sanitation Information System (SNIS), Brazil has significant discrepancies when comparing different regions of the country. Southeast, Midwest, and South have the highest water supply indices (91.2%, 89.6%, and 89.4%, respectively). However, in the Northern Region, just over half of the population has access to this service (56.9%). About sanitary sewage, the data are even more alarming since only in the Southeast, there are high rates of sewage collection network (77.2%). The other regions do not exceed 50%, reaching 8.7% in the Northern Region (Brazil, 2017).

Considering water springs and the water system for urban supply, the National Water Agency reveals that only 45% of municipalities have satisfactory conditions, 46% require the expansion of the system and 9% require a new spring supply, since many of them do not account for demand due to compromising the quality or quantity of water available (Brazil, 2015). The same agency, when analysing sanitary sewage and its implications for the water quality of the receiving bodies, indicates that sewage collection networks reach 61.4% of the urban population, but only 43% have adequate treatment. Approximately 27% of the population does not have sewage collection or treatment, and 12% use individual solutions, such as the use of septic tank (Brazil, 2017).

Recent research in Brazil showed that people living in places without access to sewage collection and water supply services showed 25.1% lower education than individuals living in households with full access to sanitation. Young people and children living in places without access to sewage collection had a school delay of 1.5% higher than the others in the same age group. Those who lived in regions with no water supply presented, on average, a school delay 1.1% higher. Considering the aspects related to the presence or absence of a bathroom, the school delay of young people living in households without this room was 7.3% higher than the average of others (Instituto Trata Brasil, 2018a; 2018b). Scriptore, Azzoni, and Menezes (2015) also found, although with reduced magnitude, the positive impact of adequate water supply and bathroom conditions on young people between 6 and 14 years on the rate of abandonment of elementary school, the distortion series-age, and the school attendance rate.

Given these premises, it is understood that the approach on basic sanitation cannot dispense with the knowledge of the perceptions and conceptions of the subjects who inhabit the context studied, providing that teachers understand these aspects under the perspective of students who represent the community in which they are acting and for which they develop their educational processes that need to be articulated with the main demands that afflict the population.

## **METHODOLOGY**

The investigative process was developed in a state school in the municipality of Estância Velha in the state of Rio Grande do Sul with the participation of 49 students from the 8th and 9th grade of middle school. With a population of 42,574 inhabitants (Brazil, 2010b), the municipality has its economy focused on the leather-footwear sector and a Human Development Index of 0.757 (Brazil, 2010b, 2015a; Old Resort, 2018).

The water that supplies the municipality comes from the Rio dos Sinos, is treated in another location, and serves 85.8% of the city's population. Only 3.2% of the population has their sewage collected (Brazil, 2017). In the urban area, the density of rainwater capture is 51%, and the type of drainage system is unitary, that is, mixed with sanitary sewage (Brazil, 2015). According to the Municipal Basic Sanitation Plan of the municipality, there are specific problems of flooding and a commitment of water quality due to the launch of solid waste and domestic sewage in the rain system (Estância Velha, 2014). Only 37.3% of households have public roads with adequate urbanisation characterised by the presence of sidewalks, street drain, and paving (Brazil, 2010b).

For the development of the present research, data collection and other activities were carried out in September and October 2017. The research project was approved by the Research Ethics Committee (CEP) in Human Beings of the Lutheran University of Brazil under the number: 73026817.3.0000.5349.

The activities were comprised of dialogue exposure, application of questionnaires in pre-activity and post-activity, work projects with the theme basic sanitation, videos on the themes addressed, and photovoice with images obtained by the students in fieldwork on basic sanitation in the municipality. This article presents, predominantly, the results obtained with photovoice, with the scores attributed to the images and with the observations contained in the logbook as a reflexive strategy of the research construction process (Zabalza, 2004).

Photovoice consists of a method that uses photography as a form of expression of subjects about the context in which they live, enabling the presentation of their perspectives and concerns revealed from the records they make, as well as the reflections and dialogue on problems in the community. Through the sharing of this knowledge, subsidies are generated for the construction of measures that can contribute to minimising the problems encountered in the place (Wang & Redwood-Jones, 2001).

The students produced 60 images to portray basic sanitation in the municipality that was analysed, producing reflections on the theme given the presence of elements and also the absences of unaddressed subjects, providing researchers to deal with these elements from the view of the community. Some of these images were added to another set of figures obtained on the internet totalling 12 photographs that were presented to students through PowerPoint to assign scores from 1 to 5, with 5 for images representing very proper scenarios, and 1 for very inadequate scenarios. Subsequently, a new round of evaluations was carried out with the same images so that the students would point out about their association with the four scopes of basic sanitation: water supply, sewage, drainage, and solid waste, considering an agreement level from 1 to 5, with 1 for “totally disagree”, and 5 for “totally agree”.

The criterion of choosing the images involved the contextual and problematic issues related to the four areas of sanitation, as well as the most frequent issues in the set of photographs brought by the students. The analysis was performed with the Kruskal-Wallis nonparametric test and descriptive statistics tools with data transformation into percentages of agreement adding the scores “4” and “5”. In the qualitative scope, an analysis of the observations present in the logbook and the contents of the answers to the open-ended questions of the questionnaires were performed.

The set of investigative activities was carried out within the perspective of the Research with Mixed Methods with the junction of the results obtained with the different forms of collection, integrating the collection and analysis of quantitative and qualitative data, and contributing to the understanding of students’ conceptions and perceptions about basic sanitation (Creswell & Plano Clark, 2011, Dal-Farra & Fetters, 2017).

## RESULTS AND DISCUSSION

Table 1 presents the results obtained with the Kruskal-Wallis nonparametric test applied to the mean scores considering the adequacy of the scenario about basic sanitation conditions.

Table 1  
Average scores of the images evaluated by the students of the 8th and 9th grade of middle school\*

Image	10	2	9	11	12	1	7	4	8	5	3	6
Average Scores	4,69	4,13	3,93	3,84	3,76	3,53	2,80	2,56	1,44	1,33	1,27	1,24
	a	ab	b	b	b	b	c	c	d	d	d	d

\*Different letters indicate significant differences ( $p < 0.05$ )

It is perceived the formation of practically four distinct groups of images, the first being composed of images 10 and 2 and the latter also composing the second group with images 9, 11, 12, and 1. There is a third group with images 7 and 4, and a fourth group with images 8, 5, 3, and 6.

As can be seen in Tables 2 and 3, image 10 represents a solid waste deposition site selectively presenting an average score of 4.69. The fact that there is no excess product and the boxes are clean makes the scenario favourable, besides presenting the possibility of separating the garbage. Image 2 presents a rural environment, with a perfectly visible water spring and no signs of solid waste deposition, or even sewage being dumped on-site, which explains the high mean score of 4.13.

The second group has image 9, in which a stream is channelled, and the mean score was high (3.93), indicating that students consider it an appropriate scenario probably because it presents a structure without the presence of solid waste or with dirty water. Image 11 features a tap from which clear water is coming out, justifying the high average score (3.84), as well as image 12, which presents a house in a rural environment with a water reservoir and without deposition of solid waste and with no open sewage. Image 1 features a paved street in a typical urban scene, just as students are accustomed to their city, attributing a middle score (3.53), although they should have considered the possible drainage problems arising from the soil impermeabilization.

The third group presents two street drain images, whose mean scores were of reduced magnitude, demonstrating that students did not have these structures as of high relevance. It is noteworthy that both showed signs of solid waste near it, which explains the values below 3.0, especially for image 4 (2.56) with a higher number of apparent leaves of trees in the photograph.

In the fourth group are images 8 and 6 with precarious housing scenarios, although commonly observed in many Brazilian cities, in addition to image 5 that presents an urban pathway full of solid waste and accumulation of water in an unfavourable scenario, as well as in the conspicuous flooding present in image 3.

Table 2 was constructed with the average of the scores and the association that each image had with each scope of basic sanitation: water supply, urban cleaning, and solid waste, sanitary sewage and rainwater drainage. The percentages of the agreement for each image by grouping scores 4 and 5 correspondings to “I agree” and “totally agree” are also presented. In order to demonstrate the integration of the data, Table 3 presents a compiled of information relevant to this research.

Table 2.

*Evaluation of images presented to students from 8° e 9° grade of Middle School*

Image	Average scores		Average scores in each scope of basic sanitation								% of concordance (score 4 plus score 5)*							
			ABA		LURS		ESG		DRE		ABA		LURS		ESG		DRE	
	8°	9°	8°	9°	8°	9°	8°	9°	8°	9°	8°	9°	8°	9°	8°	9°	8°	9°
10	4,71	4,67	2,67	2,33	4,50	4,19	3,04	2,57	2,75	2,52	20,8	14,3	<b>91,7</b>	<b>90,5</b>	37,5	19,1	20,8	9,5
2	4,21	4,05	3,70	3,10	3,42	2,90	2,75	2,95	3,38	3,19	<b>62,5</b>	33,3	<b>58,3</b>	19,1	25,0	23,8	37,5	28,6
9	4,21	3,62	3,25	3,00	4,04	3,67	4,00	4,10	3,75	3,90	41,7	33,3	<b>83,3</b>	<b>66,7</b>	<b>79,2</b>	<b>85,7</b>	<b>66,7</b>	<b>71,4</b>
11	3,75	3,95	4,67	4,57	2,88	2,81	2,88	2,67	3,58	2,86	<b>100</b>	<b>100</b>	33,3	19,1	29,2	19,1	50,0	23,8
12	3,79	3,71	4,42	4,48	3,46	2,95	3,17	2,67	3,54	3,00	<b>91,7</b>	<b>95,2</b>	<b>54,2</b>	23,8	41,7	14,3	<b>58,3</b>	33,3
1	3,25	3,86	2,10	2,86	3,96	3,86	3,04	3,19	3,00	3,33	0,0	23,8	<b>79,2</b>	<b>76,2</b>	25,0	33,3	<b>41,7</b>	38,1
7	2,67	2,95	2,67	2,48	3,00	3,29	3,54	3,24	2,88	3,86	25,0	4,7	41,7	42,9	50,0	42,9	33,3	<b>57,1</b>
4	2,29	2,86	2,21	2,19	2,54	3,19	3,29	3,71	2,79	4,00	4,2	0,0	16,7	42,9	<b>54,2</b>	<b>66,7</b>	16,7	<b>76,2</b>
8	1,33	1,57	1,96	2,29	2,58	3,52	2,75	3,67	2,38	3,14	16,7	9,5	37,5	<b>66,7</b>	41,7	<b>71,4</b>	12,5	<b>47,6</b>
5	1,33	1,33	2,13	2,38	2,54	3,38	2,67	3,10	2,33	3,33	4,2	9,5	37,5	<b>57,1</b>	20,8	23,8	8,3	<b>42,9</b>
3	1,25	1,29	1,96	2,33	2,04	2,81	2,33	2,76	1,83	3,29	16,7	19,1	20,8	38,1	37,5	28,6	8,3	<b>47,6</b>
6	1,21	1,29	1,63	2,52	2,42	3,10	2,17	3,05	2,25	2,62	8,3	28,6	33,3	<b>57,1</b>	16,7	<b>52,4</b>	16,7	33,3






\*Relevant percentage of concordance in bold. ABA= water supply; LURS= urban cleaning and solid waste management; ESG = sanitary sewage; DRE= urban drainage



Table 3.

## Analysis of images by 8th and 9th-grade students on basic sanitation

Image		Average	Concordance (%)			Comments
Image 10		4,69		LURS 8° 91,7 9° 90,5		An expected association with LURS.
Image 2		4,13	ABA 8° 62,5	LURS 8° 58,3		Rural image without structures commonly associated with basic sanitation.
Image 9		8° 4,21 9° 3,62	LURS 8° 83,3 9° 66,7	ESG 8° 79,2 9° 85,7	DRE 8° 66,7 9° 71,4	High values of agreement with LURS, ESG, and DRE in both years, corroborating information often conveyed associating LURS and "floods."
Image 11		3,84	ABA 8° 100 9° 100		DRE 8° 50,0	All students agree about an association with ABA.  In the 8th grade, DRE obtained 50% of the agreement, but it is difficult to explain this outcome.
Image 12		3,76	ABA 8° 91,7 9° 95,2		DRE 8° 58,3	A high percentage of agreement with ABA in the 8th. and 9th. year.  In the 8th year, there was a connection with DRE, probably because it is without accumulation of water.
Image 1		8° 3,25 9° 3,86		LURS 8° 79,2 9° 76,2		Predominant association with LURS, but not to DRE because the students did not consider the asphalt as a problem.
Image 7		2,80	LURS 8° 41,7 9° 42,9	ESG 8° 50,0 9° 42,9	DRE 8° 33,3 9° 57,1	High values for DRE in the 9th year. Moderate for ESG and LURS in both years.  Image features improper disposal of waste.  There was a probable association between the street drain and the place where the sewer is launched.

Image		Average	Concordance (%)			Comments
Image 4		8º 2,29 9º 2,86	LURS 8º 16,7 9º 42,9	ESG 8º 54,2 9º 66,7	DRE 8º 16,7 9º 76,2	There were high values for ESG and DRE in the 9th year. There was a probable association between the street drain and the place where the sewer is launched.
Image 8		1,44	LURS 8º 37,5 9º 66,7	ESG 8º 41,7 9º 71,4	DRE 8º 12,5 9º 47,6	There was a high percentage for LURS in the 9th year and ESG in 8th and 9th years.
Image 5		1,33	LURS 8º 37,5 9º 57,14		DRE 8º 8,3 9º 42,9	High values for LURS and DRE in 9th year.
Image 3		1,27	LURS 8º 20,8 9º 38,1	ESG 8º 37,5 9º 28,6	DRE 8º 8,3 9º 47,6	Flood image that occurred in the municipality of the study. High values for DRE only in 9th year.
Image 6		1,24	LURS 8º 33,3 9º 57,1	ESG 8º 16,7 9º 52,4		Precarious living conditions but little association with Basic Sanitation.  High values for LURS and ESG in the 9th year associated with "dirt."

LURS = Urban cleaning and solid waste. ESG = Sanitary sewage. ABA = Water supply. DRE = Drainage.  
 Fonte: image 1. <http://twixar.me/Fvq1>, image 2. <http://twixar.me/c1H1>, image 3. <http://twixar.me/fTH1>, image 4. photovoice, image 5. <http://twixar.me/RmH1>, image 6. <http://twixar.me/X1H1>, image 7. photovoice, image 8. <http://twixar.me/51H1>, image 9. <http://twixar.me/jmH1>, image 10. <http://twixar.me/BTH1>, image 11. <http://twixar.me/3mH1>, image 12. <http://twixar.me/MmH1>.

Table 2 shows that the average scores for each image were similar comparing the 8th with 9th grade, except for image 9, in which the 9th year students were able to understand the possible effects of plumbing system obliterating the contact of the population with the stream (8th. 4.21 and 9th. 3.62), the image 1 associated with solid waste and image 4 associated with sanitary sewage, although both would have to present higher agreements with urban drainage, which occurred only in image 4 in the 9th year (76.2%). In general, different data provides the understanding that drainage was the unknown scope of basic sanitation by students.

Table 3 shows that 9th students can see an association with drainage (images 3 and 5), solid waste (images 5, 6, and 8) and sanitary sewage (images 6, and 8). However, it is considered that the percentages linked to drainage should have been much higher in images 3 and 5 because they are showing flooding scenarios.

Image 1 was predominantly associated with solid waste. It is noticed that the students were unable to make an association with the aspects related to urban drainage, although asphaltting is one of the leading causes of flooding in urban environments. Often there is no drainage system, or this is inefficient. This action increases the occurrence and magnitude of floods by increasing surface runoff and difficulting underground runoff (Tucci & Bertoni, 2003; Tucci, 2008).

It is verified that image 9 received relevant percentages for drainage (66.7% and 71.8%), sewage (79.2% and 85.7%), and solid waste in the 8th year (83.3%). It is inferred that, although they understand the relationship of the image with drainage, there seems to be a perception that the water spring is also a place where sewage and solid waste are launched, corroborating what Ratter points out (2009) stating about the growing dumping of waste and domestic effluents as one of the leading causes of degradation of water resources, generating deleterious impacts on all life forms.

Although the evaluations by scores and percentages highlighted this aspect, there was a greater awareness of the students about the impacts of basic sanitation on water springs. As pointed out by the student 12:

*[...] sewage and urban drainage are not the same things, but many people think they are. Drainage has its path in order to bring rainwater to the river again, repeating the natural cycle of water, only many people end up putting sewage pipes in the drain path and thus contaminating the rivers (Student 12).*

This awareness was especially noted concerning Rio dos Sinos since 87.5% of 9th students indicated that it was crucial for the supply of water in the municipality when answering the open questions. In the 8th year, this percentage was lower (54.5%). When considering another question about the importance of the streams, many students did not know or did not answer their relevance (72% in 9th grade and 91% in the 8th grade). Three students also associated them with the “sewage launch site.”

It is also noticed that there was a higher average score for the channelled stream (image 9) than for the stream without the channelling (image 6), that is, depending on the context, the stream can be something good, provided that there is no apparent dirt. The stream in image 6, visibly polluted, was not associated with water supply (8.3% and 28.6%) and obtained the lowest mean score (1.24).

Therefore, the importance of continuing studies and actions in the community aimed at the resignification of streams, called “ditch” by common sense, expanding the perception and knowledge of the population regarding its relevance to the quality of life and for the environment as a whole.

In the scenario of image 6, it is observed the absence of a view at the water spring as the potential for water supply and, according to the percentages of agreement of the

images, it can be inferred that, in the students' perception, "water comes from the tap" (image 11) and "of the water reservoirs" (image 12).

However, a portion of the students showed concern about the impacts of sanitation on the water springs associated with sewage treatment and its correct disposal, alluding to health, environment, and social issues. As mentioned in the statement of the student 12 of the 9th year:

*[...] not all people are aware of the fate of their sewage; by law the treatment plants should treat it to return it to the river in a better quality than [...] the consequences of this are dangerous, this untreated sewage goes to the ground and contaminates the water table contaminating water (Student 12).*

There were high scores for image 10 related to the disposal of solid waste with the highest mean scores (8th 4.71 and 9th 4.67). In view of these results, it is possible to construct educational practices involving systemic characteristics to the areas of sanitation and its importance to the promotion of quality of life and the protection of the natural environment, especially with regard to water resources contributing to the participation of the population in the environmental care (Brazil, 2009).

More than evaluating the images, this strategy seeks to broaden student's perceptions and sensitise them about contemporary environmental themes, such as basic sanitation, generating the feeling of belonging to the site based on the premise: "what I know, I take care of it."

It is reiterated that the image representing a field (image 2) showed no significant difference in relation to a drainage-oriented construction (image 9) corroborating the premise that the plumbing of water springs, even if it makes them disappear from the scenario, is not considered inadequate by the residents, since there is no perception of dirt or unpleasant odours. That is, only what is noticeable/visible worries people. It is noteworthy that, in this case, these are urban residents, not commonly related to the natural/rural landscape.

This contradiction occurred mainly because, in Brazil, the cities have a small percentage of sewage treatment. Therefore, despite the need to have open water springs and with preserved riparian forest, the plumbing has been considered positive by the population due to the persistent odor from sewage launched into water springs without treatment. The presence of street drain images (images 7 and 4) in this stratum is probably associated with the fact that they drain rainwater, but also carry sewage, explaining their presence in a group close to "neither adequate nor inadequate" scores.

The last stratum images showed mean scores below 1.50. It is also noteworthy that, according to the logbook, at the time of the activity, many students made mentions of the place of the flood image, identifying that the fact had occurred in the municipality, evidencing the relevance of contextualization to learning about this theme.

For Kato and Kawasaki (2011) the relationships established with daily life contribute to the construction of meaning to the curricular content, connecting what is learned in school and what is done, lives and observes on a daily basis providing the awareness of individuals and the construction of knowledge in the community through reflections aimed at changing attitudes about local problems. It is essential to highlight the relevance of the images obtained with the photovoice that privileges learning experiences from the use of them, contributing to the construction of knowledge and the understanding of the surroundings (Shell, Ferguson, Hamoline, Shea, & Thomas-Maclean, 2009).

Considering the images brought by the students about basic sanitation, there was a greater engagement in the 9th year (41 images) than in the 8th (19 images), including the fact that the four scopes were contemplated in the photographs. In the 8th year, the sanitary sewage was not present (Table 4).

Table 4  
*Images from photovoice by students of the 8th and 9th year of middle school*

Categories	8° year		9° year	
	n	(%)	n	(%)
Street drain	11	57,9	18	43,9
Urban cleaning/solid waste	4	21,1	9	21,9
Water supply	2	10,5	6	14,7
Urban drainage/drainage grids	2	10,5	7	17,1
Sanitary sewage	0	0	1	2,4
Total	19	100	41	100

There was a predominance of images linked to the street drain probably because of the greater visibility of such structures in the urban environment, being present in the daily lives of students, and constituting a focus of community perception.

Thus, the contextualised approach to sanitation in the school environment is necessary, expanding community perceptions about the essentiality of this component of contemporary life, contributing to understanding and action in the context in which we live. It is interesting to point out that the previous conceptions on the subject many students pointed out the relationship between these structures and sanitary sewage. It is perceived, therefore, the need to discuss the differences between sewage and urban drainage for some students, and the latter consists of:

*Drainage of sewage (Student 18, 8°)*

*Drainage made in the city (water or sewage) (Student 16, 9°)*

*Drains sewage (Student 28, 9°).*

These results were also evidenced in the evaluations of the images (Table 2) in which higher scores for sewage were observed in scenarios associated with urban drainage (image 4: drainage 46.4%, sewage 60.4%; image 7: drainage 45.2%, sewage 46.4% and image 9: drainage 69.0%, sewage 82.4%). However, from these manifest perceptions, it was possible to intervene and contextualise about particularities and differences between drainage and sanitary sewage.

Kato and Kawasaki (2011) emphasise that teaching in a contextualised way implies bringing the scientific content closer to the knowledge brought by students, providing them to improve their knowledge on the theme studied.

Currently, the use of drainage systems for sewage runoff represents a problem existing in many Brazilian municipalities. With the growth of municipalities and the absence of investments in basic sanitation, the number of clandestine links of cloacal sewage directly in the rain depletion network increases, flowing directly to the water spring and causing a high environmental impact (Tucci & Bertoni, 2003).

In this scenario, actions similar to those carried out by this research contribute to the awareness of the community, as well as are promoters of a greater understanding of the possible consequences of the inadequacy of these services. It is possible to infer that, after the proposed activities, the conceptions related to urban drainage gained closer contours of the technical concepts present in the legislation, as pointed out by students:

*There is urban drainage, rain drainage, which are the same thing, rain or urban drainage is water collected from rain (Student 26).*

*Drainage that is technically the wolf mouths that serve not to be flooded, all this serves for people's health and to keep a city clean without floods and accumulation of garbage (Student 3).*

According to Cavé (2011), this is one of the main current concerns associated with the problems of management, awareness, and information of the population regarding the proper separation and disposal of these materials. In this context, a school is a place of excellence for reflections on the reduction of waste volume and environmental impacts related to the subject. According to Evaristo et al. (2017), these procedures are based on principles of conservation of the environment from the construction of knowledge, social values, skills, attitudes, and competencies.

Regarding the higher perception about solid waste, this question corroborates the data found in the 8th year, considering that the evaluation of the image related to the scope received a significant percentage of agreement. Figure 1 shows some images obtained with photovoice by students of the 8th and 9th grade, demonstrating the association performed between wolf mouths and solid waste.



Figure 1. images sent by students of 8th and 9th year of middle school about basic sanitation. A, B e E from 8th year and C, D, F, G e H from 9th year

In this perspective, a broader look at the interrelationships between the four areas of basic sanitation and expansion of students' perception of this process is beginning.

From the photovoice, the students mainly showed concern about the wrong destination of solid waste, as well as with the precariousness of part of urban structures related to basic sanitation. The methodology also provided us to understand the need to expand their perception of basic sanitation and its implications in urban life, requiring that more integrated actions be carried out and that they can have repercussions on the

community whose basic sanitation concept lacks a more marked look at conceptual dimensions and more endowed with a systemic perspective of approach and construction of actions.

## **FINAL CONSIDERATIONS**

The present study demonstrated the primacy of the use of images in research aimed at basic sanitation at school. Based on the evaluations, it was possible to understand the students' perceptions about different scenarios of the site articulated with the four scopes of basic sanitation.

The analysis of the scores integrated with the observations of the logbook provided verifying the difficulties of students to perceive the drainage and management of rainwater as a component of basic sanitation along with the other areas that compose it: sewage, water supply, solid waste and urban cleaning, demanding that educational practices articulated with the themes addressed each year can integrate the broad aspects that constitute this vital component of life urban in contemporaneity.

The use of Mixed Method Research enabled the integration of qualitative and quantitative data emerging peculiarities that made it possible to clearly understand the perceptions and conceptions of students through the merge of the data in a Convergent Design, especially the difficulty of perceiving the stream as associated with the water supply, as well as the perception that, if tap water is coming out and, if there is no sewage odour or accumulation of solid waste near the dwellings, the population feels good and cares about the issue.

In the light of the results obtained and since the improvement of basic sanitation conditions represents a fundamental element for the development of circumstances favourable to quality of life and social development, it is suggested that they be carried out more research of this nature articulated to the experiences of students aimed at building skills and skills that contribute to reflection and critical action in the face of socio-environmental challenges in contemporary life.

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## **STATEMENTS OF CONTRIBUTIONS FROM THE AUTHORS**

R.A.D.F and M.M.A., performed field and data collection activities. Both authors analysed, discussed, and elaborated the version of this scientific paper.



## DATA AVAILABILITY STATEMENT

The data supporting the results of this study will be made available by the corresponding author, R.A.D.F., upon reasonable request.

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# Selection and Application of graphical and numerical statistical tools by prospective primary school teachers

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## ABSTRACT

Teaching statistics in the early years requires that teachers at this school level develop skills to analyze small collections of data. Given a collection of quantitative data (12 observations), in this paper we looked at how students and prospective primary school teachers select and make appropriate graphs and identify and determine statistical measures suitable for summarizing the data, including the interpretation of the third quartile. The study involved 50 students who were attending the 2<sup>nd</sup> year of the Basic Education Bachelor's program at a university in northern Portugal. The collected data correspond to the answers given by the students in a formal examination in a Probability and Statistics course. An analysis of the answers showed that the students had difficulties in both the selection and application of statistical methods, which were more pronounced when they had to identify the appropriate graphs to represent the data and to determine the quartiles and to interpret the third quartile, and less pronounced in the case of determining other statistical measures.

**Keywords:** statistical graphs; statistical measures; prospective primary school teachers.

## Escolha e aplicação de ferramentas estatísticas gráficas e numéricas por futuros professores dos primeiros anos

### RESUMO

O ensino da Estatística nos primeiros anos de escolaridade requer que os professores desse nível escolar desenvolvam competências de análise de pequenas coleções de dados. Neste artigo, estudamos a habilidade de, perante uma coleção de 12 observações de tipo quantitativo, estudantes, futuros professores dos primeiros anos escolares, selecionarem e construírem gráficos adequados e identificarem e determinarem medidas estatísticas convenientes à sumarização dos dados, incluindo a interpretação do 3.º quartil. No estudo participaram 50 estudantes que se encontravam a frequentar o 2.º ano da Licenciatura em Educação Básica numa universidade do norte de Portugal. Os dados recolhidos correspondem às respostas dadas pelos estudantes numa prova de avaliação formal da disciplina de Probabilidades e Estatística. Em termos de resultados, uma análise das respostas

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permitiu verificar que os estudantes revelam dificuldades tanto ao nível da escolha como da aplicação dos métodos estatísticos, mais acentuadas quando se tratava de identificar os gráficos adequados para representar os dados, e de determinar os quartis e interpretar o 3.º quartil, e menos acentuadas no caso da determinação de outras medidas estatísticas.

**Palavras-chave:** gráficos estatísticos; medidas estatísticas; futuros professores dos primeiros anos.

## INTRODUCTION

We have been witnessing an increasing use of Statistics in different areas of society both at the personal and professional level, which explains its more in-depth teaching at schools. In Portugal, the content of Probability and Statistics courses which are part of the Data Organization and Treatment subject, are included in the Mathematics program in all school grades, both Elementary Education (Ministério da Educação e Ciência, 2013) and in Secondary Education (Ministério da Educação e Ciência, 2014).

Therefore, in line with school programs, a more in-depth teaching of Probability and Statistics at school requires that teachers also get education in mathematics that enables them to teach these subjects according to the needs of their students and the education system. It is particularly important for teachers in the first school years to learn the basics of Descriptive Statistics for their teaching and the basic skills to design or prepare simple research activities involving standard, graphical and numerical statistical tools to summarize qualitative and quantitative data (discrete or continuous data).

Around one decade ago, Batanero (2009) warned that the teaching of Probability and Statistics was usually not part of the initial education for all teachers. For primary school teachers, this issue is possibly even more serious because only recently, more precisely in the beginning of the century (Ministério da Educação, 2007), these contents were included in school programs and, as a result, in the initial education of these teachers.

Therefore, in the context of the initial education of prospective primary school teachers, this study looks at the statistics knowledge and skills of these prospective teachers in Descriptive Statistics. More specifically, it assesses the suitability of the exploratory statistical methods selected by the prospective teacher for a quantitative data analysis involving graphs and statistical measures, as well as the appropriate application of these methods.

The right selection of exploratory methods for preliminary data analysis is of utmost importance because, on the one hand, it is the first step to explore more open tasks, as is the case with investigative projects in Statistics and, on the other hand, it underlies the understanding of strategies used to solve even simple exercises and problems, which can lead to a deeper understanding of concepts or of the relationships between concepts. In a previous study, Fernandes, Batanero and Gea (2019) looked at the suitability of the statistical methods chosen by prospective primary school teachers to analyse a data set related to a qualitative (nominal) variable and concluded that they had more difficulties in selecting the statistical methods.

In the present study, which is a follow-up study aiming to complement the previously mentioned study, we analyse the knowledge and skills of prospective primary school teachers in selecting the statistical methods (graphs and measures) to analyse a data set related to a continuous quantitative variable. The type of statistical variable, i.e., either a qualitative variable (nominal or ordinal) or a quantitative variable (discrete or continuous) is extremely relevant in a statistical study because it dictates the statistical methods that can be applied.

In the next sections, we will present the theoretical framework and the background, reporting and discussing some studies related to the issue investigated here; the research method, where we explain the type of study, the participants and the data collection and analysis methods; the presentation of results according to the graphical contents and statistical measures; and, finally, we summarize and discuss the study conclusions.

## **THEORETICAL FRAMEWORK AND BACKGROUND**

Research on the knowledge teachers should have to successfully teach Mathematics has resulted in several frameworks. For the purpose of our study, from the theoretical models most frequently mentioned in the literature (Gonzalez & Eudave, 2018), we chose the Mathematical Knowledge for Teaching (MKT) framework, which is widely quoted and originally proposed by Ball (2000). This framework characterizes the mathematical knowledge teachers should have to carry out their teaching activities and enhance the learning of mathematics, classifying the mathematical knowledge of teachers into two categories: Content Knowledge and Pedagogical Content Knowledge and is based on Shulman's framework (1986) which classifies teacher's knowledge into three categories: Content knowledge, pedagogical content knowledge and curriculum knowledge. Content Knowledge includes mathematical knowledge and the transformation of this knowledge to make it accessible to students, while in Pedagogical Content Knowledge relationships are established between the mathematical knowledge and several factors such as students, teaching and the curriculum.

Since in this study we are investigating the mathematical knowledge of prospective teachers, we have limited the investigation to Content Knowledge, which consists of the three following subcategories (Hill, Ball & Schilling, 2008):

- Common Content Knowledge (CCK), which consists of the knowledge adults use to solve mathematical problems;
- Specialized Content Knowledge (SCK), which relates to the special knowledge teachers need to plan and implement their teaching sequences;
- Knowledge at the mathematical horizon, which refers to the knowledge of the sequence of mathematical topics in the curriculum, with teachers relating what their students are learning with what they will learn in the future.

Of these three subcategories we will discuss Common Content Knowledge and Knowledge at the Mathematical Horizon, because in this study we will not look at issues related to Specialized Content Knowledge.

Since we are dealing here with prospective primary school teachers, it is extremely important that during their education they acquire skills that will enable them to decide which methods to use in (simple) statistical data analyses, e.g., in investigative projects. According to Batanero, Díaz, Contreras and Arteaga (2011), open tasks are widely used today because they enhance students' motivation and reveal the context and its realistic nature. Furthermore, these tasks enable students to acquire strategic knowledge that is added to the technical knowledge applied in conventional tasks.

Additionally, statistics studies, such as investigative projects, involving more open tasks, can have several steps, as advocated by Wild and Pfannkuch (1999) when they proposed the PPDAC framework, which they call investigative cycle, divided into five steps: problem (P); plan (P); data (D); analysis (A) and conclusions (C). We will focus particularly on the second and fourth steps, related to the planning and implementation of tasks designed to solve a problem or give an answer to the investigation questions defined in the previous step. Decisions are made in the second step regarding which statistical analysis/methods or statistical measures are appropriate for the study, while in the fourth step the previously selected methods/procedures are applied.

The type of statistical variable being studied determines, to a great extent, the statistical methods that can be used in the data analysis regarding frequency, statistical measures or the statistical graphs, thus impacting the planning and analysis steps. Regarding frequency, it is essential for their teaching that prospective teachers are able to relate the concept to the procedure. While absolute and relative frequencies can be determined for any type of variable, accumulated absolute and relative frequencies cannot be determined in nominal statistical variables because these frequencies require the establishment of an order relationship. Thus, accumulated frequencies can only be determined for an ordinal qualitative variable or quantitative variable. However, we know that if some statistical methods cannot be used in certain situations, because they require numerical data, students incorrectly use frequencies to overcome the issue of the values of qualitative statistical variables (Fernandes & Barros, 2005; Fernandes, Carvalho & Ribeiro, 2007; Fernandes, Carvalho & Correia, 2011).

Additionally, the choice of graph used to represent data is very important because it may impact the success of the next PPDAC steps. Regarding the media, it is expected that any individual with mathematical education will be able to interpret the various types of graphs; but making graphs or deciding which one is more adequate considering a given data set (qualitative or quantitative, discrete or continuous, a few or a lot of data) requires a deeper knowledge and is not always easy to realize. For example, Morais and Fernandes (2011) and Fernandes, Morais and Lacaz (2011) found that 9<sup>th</sup> grade students had difficulties when choosing the right graphs to represent data. In the three items proposed to students, the best performance was achieved in the one that involved the graphical representation of a discrete quantitative variable (age), followed by the one that

asked a graphical representation to compare the values of the previous variable according to the variables male and female gender and, finally, a very poor performance in the item that required the graphical representation of a continuous quantitative variable.

Students clearly preferred to make simple bar graphs. When this graph was adequate to represent the variable, the proportion of correct or partially correct answers was high; however, when this graph was not appropriate to represent the variable, there was a significant reduction in the number of correct and partially correct answers. This reduction was particularly pronounced when the item involved making a histogram, when almost half of the students did not answer and except for one student who gave a correct answer and another student who gave a partially correct answer, all other students made bar graphs, pie charts, line graphs and Cartesian graphs. According to Fernandes et al. (2011),

the prevalence of simple bar graphs could result from the fact that this type of graph was the one most practiced by these students during the classes and also because it is easier to make than the other types of graphs, for example, the grouped or stacked bar graphs or histograms. (p. 11)

In addition to choosing a graph that was not adequate to represent the data, the graphs made by the students presented many flaws described in the literature (e.g. Espinel, González, Bruno & Pinto, 2009; Ruiz, Arteaga & Batanero, 2009), like the absence of a title and axis labels, inadequate scales and careless graph making. According to Friel, Curcio and Bright (2001), these aspects, which they call graph structure, are important because they provide information on the type of measurement that is being used and the data that are being measured. We should stress here that changing the scales can distort the shape of a bar graph and of a histogram, which in turn can result in wrong interpretations by individuals with less mathematical education. Also in the representation of data in a box plot, a less conventional graph that is widely used in exploratory studies in several areas of knowledge, there are well-recognized difficulties, particularly regarding its interpretation (Carvalho, Fernandes & Freitas, 2019).

Similarly, the choice of statistical measures to summarize data depends on the type of statistical variable being studied. Except for mode, which is a kind of statistics that can be applied to any type of variable, none of the other measures of location (median, quartile and mean) and dispersion (amplitude, variance and standard deviation) can be applied to every type of statistical variable. However, as shown in the literature (e.g., Boaventura & Fernandes 2004; Fernandes et al., 2007), when it is not possible to determine the median or the mean, because it is a nominal qualitative variable or a non-quantitative variable, respectively, students use frequencies to obtain numerical values that enable them to apply formulas to calculate these statistics.

In the study by Fernandes et al. (2007), when the teacher asked 7<sup>th</sup> grade students to calculate the mean, the mode and the median of the variable color of the eyes of the students in the class, she found that students were confused and found it difficult to calculate the



median and the mean, with one student suggesting: “We could transfer this to a number: we could have blue 1, green 2 and so on” (page 49). Then, when the teacher reminded them that to calculate the median they should order data, another student added: “Only if we did it by alphabetical order.” In these excerpts we can see how students insist to wrongly overcome the non-existence of numerical values which they know are required to determine statistics.

In the study by Boaventura and Fernandes (2004), given the distribution of a nominal qualitative variable (the students’ favorite beverage), 12<sup>th</sup> grade students were asked to determine, if possible, the mode, median and mean, and they found that many students had difficulties solving the task, particularly the median and the mean. Regarding the median and the mean, students used the frequencies of the variable values to determine these statistics and, for the mode, many students indicated the frequency instead of the variable value. Fernandes and Barros (2005) also found similar results, this time with prospective primary school teachers.

In a more recent study involving the same nominal qualitative variable (the students’ favorite beverage), Fernandes, Batanero and Gea (2019) found that around half of the students, who were prospective primary school teachers, determined accumulated absolute and relative frequencies, which is not right, around three out of four students made a bar or pie chart, which is adequate, almost all of them (82%) indicated the mode value, which is equally right and many (78%) determined the value of the mean, the median, the standard deviation, quartiles, amplitude or variance, which are clearly not the right statistical measures for the study variable. Students found it more difficult to choose the statistical methods than to apply them, particularly in the case of frequencies and statistical measures.

In our study we looked at the extent to which prospective primary school teachers select and apply statistical analysis methods that are adequate to a given data distribution that involves a continuous quantitative variable regarding graphs and statistical measures.

## **METHOD**

In this mainly descriptive study we investigated the choices of statistical methods regarding graphs and statistical measures made by students, prospective primary school teachers and the later application of these methods in the analysis of a statistics task.

The study included 50 students ( $E_i$ , with  $i = 1, 2, \dots, 50$ ) from a university in northern Portugal who were attending a Probability and Statistics course in the 2<sup>nd</sup> year of a Basic Education Bachelor’s program. When entering the university, these students had very different levels of mathematics education, which also explains the diverse perceptions of their difficulties in the Mathematics courses they had attended so far at the university.

Data collection was made through a formal exam that students took after the end of the Probability and Statistics course. This curriculum unit is focused on content knowledge and it does not explore teaching aspects. Of the several tasks included in the exam, we looked at just one (Figure 1), focused on a set of 12 observations of a continuous quantitative variable. To solve this task, students could use a calculator or a computer calculation sheet.

The chart below shows the grades, in a 0 to 100 scale, obtained on a Mathematics exam by twelve 5<sup>th</sup> grade students.

55	60	84	45	48	64
90	65	55	58	70	50

a) Which type of graphs properly represents the data? Choose one of these graphs and represent the data.

b) If possible, identify the mode and determine the mean, quartile and standard deviation values. In general, what is the meaning of the third quartile?

Figure 1. Task statement proposed to the students

In terms of data analysis and organization, we started by listing the chosen statistical graphs and then proceeded to identify failures in the graphs made by the students regarding question a); then we assessed the determination of the six statistical measures required (mode, mean, 1<sup>st</sup> quartile, median, 3<sup>rd</sup> quartile and standard deviation) according to the type of answer (correct and incorrect) and the interpretation of the third quartile in question b). If applicable, we determined the students' frequencies according to the different types of answer (correct or incorrect) and not answered, information is summarized in tables and examples of problem-solving by the students are presented to clarify their reasoning.

## RESULTS AND ANALYSIS

In this section, we present the results obtained according to the content of the task questions: a) graphs; and b) statistical measures.

### Graphs

In question a) students are asked which graphs are adequate to represent the provided data and, then, they are asked to make one of these graphs to represent the data. Taking into account the continuous nature of the data and the lessons learned by the students, the most adequate graphs would be histograms or box plots and given the reduced number of observations (12), a stem-and-leaf plot. In the problem context, students could also group data in classes/categories and, thus, select the graphs most suitable to the qualitative variables, namely a bar or pie chart. Although the latter two charts were marked, students did not point to any type of previous data categorization. In addition to these graphs, students indicated and/or made other inadequate graphs, as shown in Table 1.

Table 1

*Frequencies of the types of graphs indicated and made by the students.*

Type of graph	Number of students (%)	
	Graphs indicated	Graphs made
Histogram	35(70)	24(48)
Stem-and-leaf plot	3(6)	2(4)
Bar chart	36(72)	12(24)
Line graph	7(14)	3(6)
Pie chart	5(10)	—
Scatter diagram	5(10)	—
Frequency table	2(4)	1(2)
Grouped bar chart	1(2)	—
Not answered	1(2)	8(16)

By analysing the choice of graphs made by the students, we concluded that, on average, each student indicated two different types of graphs to represent the data. However, more inadequate (56) than adequate graphs (38) were mentioned and the box plot was not mentioned as an adequate graph to represent the data.

Regarding the graphs that were considered adequate we highlight the histogram, which was mentioned by over half of the students (70%), followed by the stem-and-leaf plot, although at a much lower frequency (6%).

Regarding the graphs that were considered inadequate, the bar chart was mentioned by over half of the students (72%), being the most frequently chosen, followed by the line graph (14%), the pie chart and the scatter diagram (both with 10%), the frequency table (4%) and the grouped bar chart (2%).

Therefore, in general students performed poorly when asked to indicate which graphs were adequate to represent the data. In addition to the bar chart, the line graph and the pie chart, which are not adequate because data are almost all distinct, it is even more difficult to understand why they mentioned the scatter diagram, which applies to two-dimensional distributions, thus involving two statistical variables, and the frequency tables.

In the graphs made by students to represent the data, we highlight the use of the histogram by around half of the students (48%), which is a graph that is adequate to the given situation. However, many students used many different classes, 10 classes (8%), 6 classes (14%), 5 classes (16%), 4 classes (2%) and 3 classes (8%), when, for a set of twelve pieces of data, it would be adequate to use 3 or 4 classes (using the Table by Truman L. Kelly or the rule of the sample size square root). In three of these graphs separate bars were considered. Figure 2 shows an example of a histogram with 10 classes. In the case of stem-and-leaf plots, the students did not specify either the stem or the leaf units.

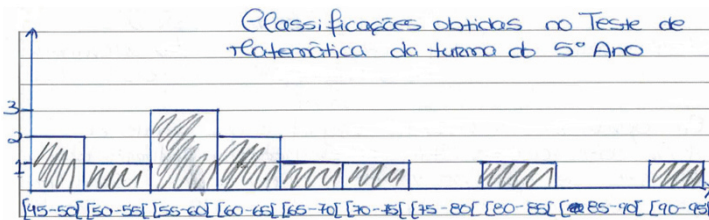


Figure 2. Graph made by student E41 for question a)

Although it was not adequate, a reasonable percentage of students (24%) made a bar chart to represent the data, as shown in Figure 3. We realize that student E4 did not pay attention to the scale of observations and considered only 11 pieces of data, forgetting datum number 58.

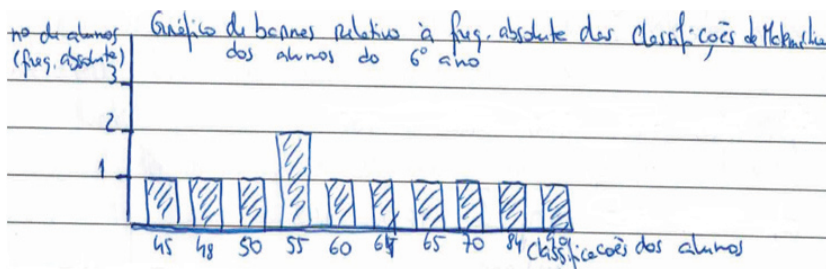


Figure 3. Graph made by student E4 for question a)

The fact that there was almost no data repetition, as is the case in this situation, results in the fact that the distribution given by the bar chart is not very different from the given gross data, with the graphical representation achieving a minimal data reduction. Some of these students (12%) consider on the horizontal axis the data labels (1 to 12) and on the vertical axis their classifications, as shown in Figure 4.

In this representation there is no data reduction whatsoever, all that was done was to represent the data provided in the task statement in a bar chart. This kind of difficulty was also observed by Fernandes and Correia (2009) in some practicing primary school teachers.

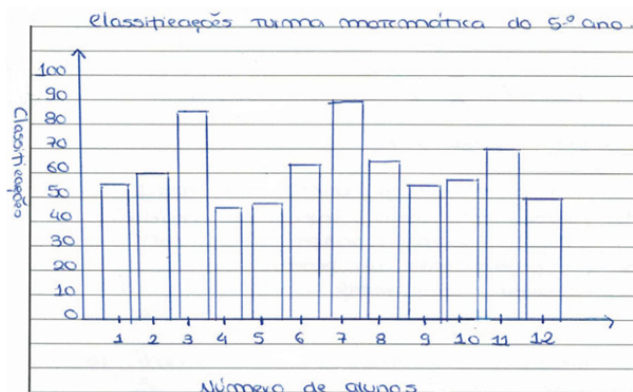


Figure 4. Graph made by student E4 for question a)

Additionally, we found that students often either did not give a title to the graph or named the respective coordinated axes. Of all graphs, 32% did not have a title, 26% did not name the horizontal axis and 24% did not name the vertical axis.

### Statistical measures

In general, in question b) students considered that it would be possible to determine the mode, the mean, the quartiles and the standard deviation. Table 2 shows the frequencies of students according to the type of response (correct and incorrect) and of questions not answered.

Table 2  
Frequencies of types of answers in the different statistics

Type of answer	Number of students (%)			
	Mode	Mean	Quartiles	Standard deviation
Correct	50(100)	43(86)	14(28)	26(52)
Incorrect	—	6(12)	29(58)	16(32)
Not answered	—	1(2)	7(14)	8(16)

Except for one student, who mentioned the modal class, all other students mentioned the mode value of the simple data. Similarly, almost all students (86%) properly determined the mean value, out of whom two (4%) used the class marks instead of the values of the statistical variable; and some answers were wrong because of calculation errors (12%).

Determining quartiles was a difficult task for the students, with few of them (28%) correctly determining the three quartiles. The majority (58%) determined at least one



value of the third quartile is not a value found in the collected data, and therefore, under these circumstances, the percentage of values greater than or equal to the value of the third quartile is the complement to 100% of the 75% (for further details on the issue of the correct interpretation of quartiles linked to the existence of observations equal to the value of the quartile in the collected data, see, for example, Freitas, Cruz & Silva (2017) for the specific case of the second quartile).

In addition to the high percentage of unanswered questions (34%), incorrect assignment of meanings was mainly due to inaccurate statements made by the students (14%), by confusing the third quartile with the first quartile or the median (8%), by confusing the third quartile with the mean or the mode (4%) and by confusing the third quartile with an extreme value (2%). These results show that, just like in the determination of quartile values, students also have many difficulties to interpret the third quartile.

## CONCLUSIONS

In the present study, we investigated students and prospective primary school teachers regarding two fundamental steps in a statistics assignment: the selection of methods (graphical and numerical) used in a statistical analysis, followed by the application of these methods.

Considering the overall performance of the students in question a), we found that 76% indicated an adequate graph, but out of those, only 22% indicated only one adequate graph, meaning that most of them presented, in addition to the adequate graph, at least one graph that was not adequate for the given situation; 52% made an adequate graph which could, however, have flaws in its structure. In question b), considering the determination of statistical measures and the interpretation of the third quartile, on average, 60.8% gave a correct answer.

These results show that the question involving the choice of graphs that would properly represent data and making one of these graphs caused the greatest difficulties for the students, and the choice of inadequate graphs and the omission of structural aspects in the graphs, like the title, the scale and axis labels (Friel et al., 2001) were found in studies with 9<sup>th</sup> grade students (Fernandes et al., 2011, Morais & Fernandes, 2011) and prospective primary school teachers (Fernandes et al., 2019). Many students chose to make bar charts in which, due to the virtual absence of repetition, the graphical representation cannot be distinguished from the given data. According to Fernandes and Correia (2009), graphical representation of each individual piece of data, as in this case, is the most basic level of data representation. What we have here is a graphical representation that does not result in any data reduction.

The question involving the determination of statistical measures and the interpretation of the third quartile had the highest percentage of correct answers. Generally, in the determination of statistical measures, students performed better than in the choice and interpretation of these statistics (Boaventura & Fernandes, 2004; Fernandes et al., 2007)

which, among other possible reasons, is due to a teaching more directed to techniques and procedures (Fernandes et al., 2011). Compared to other statistics, the greatest difficulty in the determination of quartiles generalizes the difficulties students have to determine the median, as shown in several studies (e.g., Carvalho, Fernandes & Freitas, 2019; Fernandes & Barros, 2005).

Comparing the results of the present study, whose data refer to a quantitative variable, with those obtained in the study by Fernandes et al. (2019), whose data refer to a nominal qualitative variable, studies with the participation of prospective primary school teachers, we find that students have not chosen very different statistical methods. However, the fact that data relate to a nominal qualitative variable or to a quantitative variable means the use of frequently different statistical methods, which apparently many students did not realize. Therefore, these students determine accumulated frequencies and several statistical measures in nominal qualitative variables, use frequencies instead of variable values for statistics and represent the data using graphs that do not significantly reduce the data, thus enabling the recognition of patterns and trends.

Therefore, regarding the identification and application of statistical methods, it seems that students think that they can apply these methods to any type of statistical variable, overgeneralizing the use of these methods.

Thus, this study concludes that prospective primary school teachers should explore, during their early education, tasks such as those proposed in this study, particularly those involving decision-making about the statistical methods to be used and the interpretation of statistical results. The practice of these tasks by prospective teachers is extremely important if we want them to explore these tasks with their future students, because these educational experiences will influence their future pedagogical practices (Almeida & Fernandes, 2010).

Considering the difficulties students had, the solution is to face instead of ignoring them, because the choice of the statistical methods and the interpretation of results are activities that are closely related to the exploration of more open tasks, application and investigative projects (Batanero et al. 2011). Not letting students decide which statistical methods they should use, because they are already specified in the task statements and not encouraging interpretation show that Statistics teaching and learning is focused on formulas and calculations, which is a limited approach considering the current recommendations for the teaching of Statistics (Fernandes et al., 2007; MacGillivray & Pereira-Mendoza, 2011).

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## **AUTHOR CONTRIBUTION STATEMENTS**

JAF was more involved with planning the study and organizing the paper, while AF had a major role regarding the statistical aspects. Both authors equally participated in writing the paper, namely the theoretical framework and background, method, data analysis and conclusions.

## **DATA AVAILABILITY STATEMENT**

The authors agree to make available the data that support the results of this study by means of reasonable request from a reader and the authors will determine at their own discretion whether the request is reasonable or not.

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