THE USE OF TINKERPLOTS FEATURES: A STUDY WITH BRAZILIAN STUDENTS

O USO DAS FERRAMENTAS DO TINKERPLOTS: UM ESTUDO COM ESTUDANTES BRASILEIROS

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Abstract

The introduction of computers in schools does not guarantee the improvement of the teaching of Mathematics and Statistics, because it is necessary to consider pedagogical approaches and the software used. In this article we discuss a study that examined the interpretation of data amongst 12 students from Year 7 of elementary school who are familiar with computing environments. In pairs, the participants used the TinkerPlots software tools: Cards, Table, and Plot. Research data was collected in four sessions, via video recordings using Camtasia Studio, and field notes during the work of students. By using software tools, students organized data so as to obtain various forms of graphical representations to develop data interpretation. This enabled the students to approach the data in an active way, making interpretations that considered various aspects of relations between data.

Keywords: TinkerPlots, Mathematics Education, Statistics teaching.

Resumo

A introdução de computadores nas escolas não garante a melhoria do ensino de Matemática e Estatística, porque é necessário considerar as abordagens pedagógicas e do software utilizado. Neste artigo discuti-se um estudo que examinou a interpretação dos dados, entre 12 alunos de 7º ano do Ensino Fundamental, familiarizados com ambientes de computação. Em pares, os participantes usaram as ferramentas de software *TinkerPlots*: *Cards, Table* e *Plot*. Os dados da pesquisa foram coletados em quatro sessões, por meio de gravações de vídeo usando o *software Camtasia* Studio, e notas de campo durante o trabalho dos alunos. Usando ferramentas de *software*, os estudantes organizaram os dados de modo a obter várias representações gráficas e desenvolver suas interpretações dos dados. Isso permitiu que os alunos se abordassem os dados de uma forma ativa, fazendo interpretações que consideraram diversos aspectos das relações entre os dados.

Palavras-chave: TinkerPlots, Educação Matemática, ensino de Estatística.

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Introduction

The statistical information provided by the media influences decisions in people's lives, and it is important to read and interpret it to understand the world. Statistical knowledge is essential for critical reflective and participatory citizenship (CARVALHO; SOLOMON, 2012). In Brazil, the recognition of the influence of statistical data in the current society demanded the inclusion of this topic in National Curriculum Parameters (BRASIL, 1997).

In state schools as well as in private schools, the use of computers to support the teaching of mathematics and statistics is a great challenge. Although Brazilian governments have provided computers in many elementary and secondary schools, it is difficult to implement the integration of computers in the school teaching routines (CARVALHO; MONTEIRO, 2012). In addition, the provision of technologies alone will not ensure significant changes in the way schools teach statistics and mathematics, because it is necessary to make sure the pedagogical approaches will be meaningful to students.

The interpretation of data is a complex human activity that involves the use of mediating tools such as graphs. Monteiro e Ainley (2010) argue that some studies seem to attribute an excessive power to graphical representation, minimising the role of the reader. In this perspective, failures and errors of interpretation could be explained as a lack of understanding or knowledge of the correct way to read a graph.

Ainley, Pratt e Nardi (2001) argue that teaching about graphs requires the development of at least three aspects: practical skills required for the manual production of graphs, knowledge about the conventions and technical aspects such as use axes and variables, and understanding how to interpret and use graphs. These authors discuss an alternative explanation for the low performance of students related to learning graphs. The authors state that in a traditional view of statistics education at primary school, the construction of graphs is often seen as the end point with little attention being given to the processes of interpretation.

In this paper, we discuss, in particular, a study that investigated the use of software TinkerPlots developed by Konold and Miller (2005) for the interpretation of data, in order to promote the learning of statistical concepts. TinkerPlots provides a dynamic environment in which students can organize and explore different graphical representations of data. Studies such as Ben-Zvi (2006) and Watson (2008) about the use of TinkerPlots in teaching statistics have given evidence about the importance of using such software tools in order to explore data.

This paper reports the first study that investigated the use of TinkerPlots in a Brazilian elementary school context. The research aimed to explore the question: 'How do students from 7th grade develop processes for interpreting data, including the use of the tools *Cards, Table* and *Plot*, when working on tasks which relate to other school topics and encourage reflection on everyday situations?'

Method

The study involved twelve 11-12 year-old students in the 7th grade of a private elementary school in Recife, Pernambuco. This school was chosen because it already had a practice of integrating the use of computers with the teaching of different disciplines. The students worked in pairs, each sharing a machine in the school computer lab. The reason for working with pairs was to encourage dialogues that could make explicit some aspects of understanding and use of software tools developed by the pair. The pairs were formed spontaneously by the students, based on their previous relationships.

Criteria established for choosing these participants allowed the formation of groups composed of students who were alike in some respects: all students belonged to the same class of the 7th grade of elementary school; all had middle-range scores in mathematics subjects, between 5.0 and 6.0; all participants had studied at that school from at least the 5th year of elementary school, and they already regularly used computers in the school environment.

Data collection was conducted in four weekly sessions, lasting an hour. The data collected were recorded in protocols developed by the researcher observations and also in video obtained through software Camtasia Studio.

Results and Analysis

In this section we offer first an overview of the activity of the students in the four sessions, and then a more detailed case-study of the work of one pair of students. This was developed though thematic analysis of the data, focussing particularly on the use of specific tools within Tinkerplots.

At the beginning of the first session, some students had a little difficulty in identifying the meaning of some functions of the software due to the fact that the menu was in English. By exploring the tools, this initial difficulty was easily overcome. At the end of this first session they showed a very good level of understanding and no difficulties in the handling of the tools.

In the second session, all pairs worked with dummy data created by the students themselves. Each chose a theme and set attributes, and then using the *Cards* tool built the database. The pairs also explored the tools *Table* and *Plot*. At the end of the second session, the students expressed the view that they had learned to use two attributes in the same plot for the purpose of interpretation.

At the end of the second session, all participants gathered to choose a topic about which to collect data to explore using TinkerPlots. All 12 students agreed to continue work on the topic of healthy food. They developed a nine-item questionnaire which asked about: name; gender; age; weight; how many meals per day; favourite food; usual drink; sport; usual snack.

In the interval between the second and third sessions, each pair received 5 copies of the questionnaire, which they gave to 5 students from 6th to 9th grade of elementary school. In total, the questionnaire was administered to 30 students. During the period before the third session, we also found out that the theme was chosen because their Natural Sciences teacher had proposed work about that topic. The teacher told us that one of the topics to be covered with students related to the classification of foods (proteins, lipids, carbohydrates etc.) and, based on this the groups would make up the food pyramid. The teacher drew attention to two current problems: the search, especially by girls, for a perfect thin body, conducting diets which were sometimes poor in nutritional value, and childhood obesity, which is increasingly common nowadays and often caused by lack of proper nutrition.

In the third session, students began to organize the data collected using the questionnaire. Each pair received copies of all questionnaires. Therefore, all pairs worked with the same data from all 30 respondents. They used the tools of TinkerPlots to organize and represent data. All pairs record data in the tool *Cards*, and constructed a *Table* with the data recorded in the *Cards*. Most pairs explored the *Plot* tool. In particular, pair 6 developed more actions, because they organized the data into categories and began to use the *Plot* tools in order to analyse the data.

In the fourth session the pairs continued the work begun in the third session, exploring the data that had been entered using the *Cards* tool. They produced several graphical representations using TinkerPlots tools.

Although, we could see from our data that all pairs were engaged in data handling processes based on TinkerPlots tools, the pair 6 protocol from session four showed in a clearer way the dialogues and the strategies for using the software tools. Therefore, in this paper due lack of space, we report examples taken only from analysis of pair 6 protocols. For example, Figure 1 shows a representation produced by pair 6 to analyse the attribute 'usual snack'.
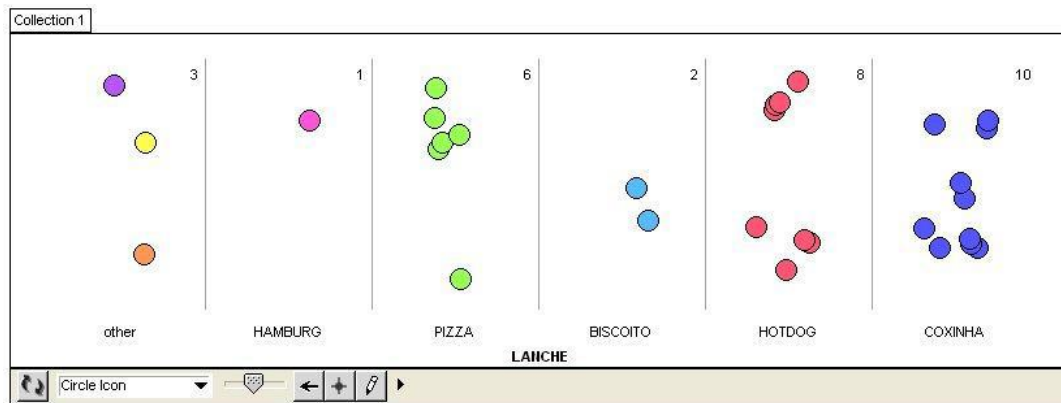
Figure 1. Pair 6 representation of the Snack attribute.

Based on their analysis of the graph produced, pair 6 wrote a comment in a text box: "the coxinha [a kind of croquette] is the favourite snack for most people. That means they eat more fried food as snack." In another graph (see Figure 2), pair 6 looked at the relationship between the attribute Weight2 (categories: Underweight, overweight, average) and Favourite food (Pasta; Fruit; Frying; Cereals). They also wrote in a text box: "people who are overweight are the ones who eat more pasta and frying. So these foods make people fatter."
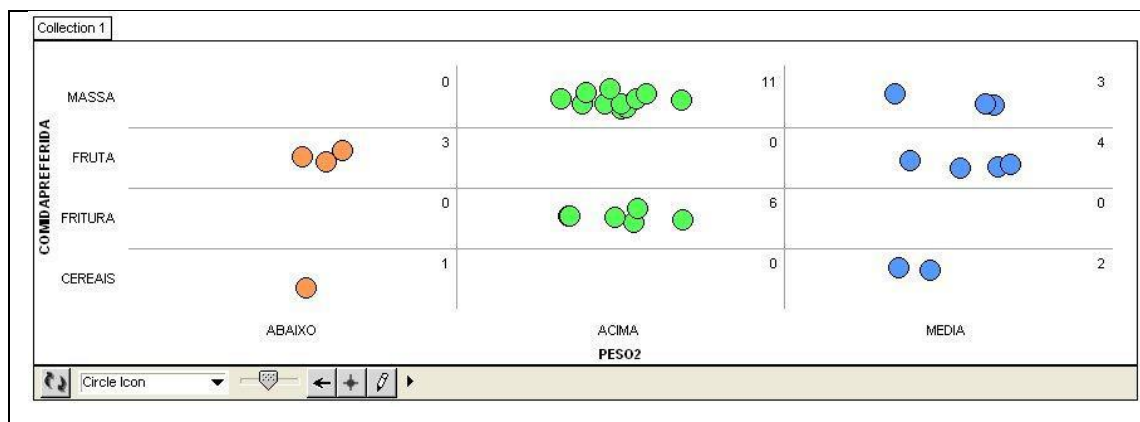

Figure 2. Graph that shows the relationship between weight2 and Favourite food.

The possibility of making changes to the representations and showing relationships within the data, encouraged pair 6 to reflect on the data, and explore other possibilities using the TinkerPlots tools. In their exploration and discussion with each other, they decided to produce a bar graph (Figure 3), because according to one of students: "it is easier to read". Therefore, they plotted the relationship between weight (kg) and kind of snack (biscuit; coxinha; fruit; hamburger; hotdog; nothing; popcorn; pizza).
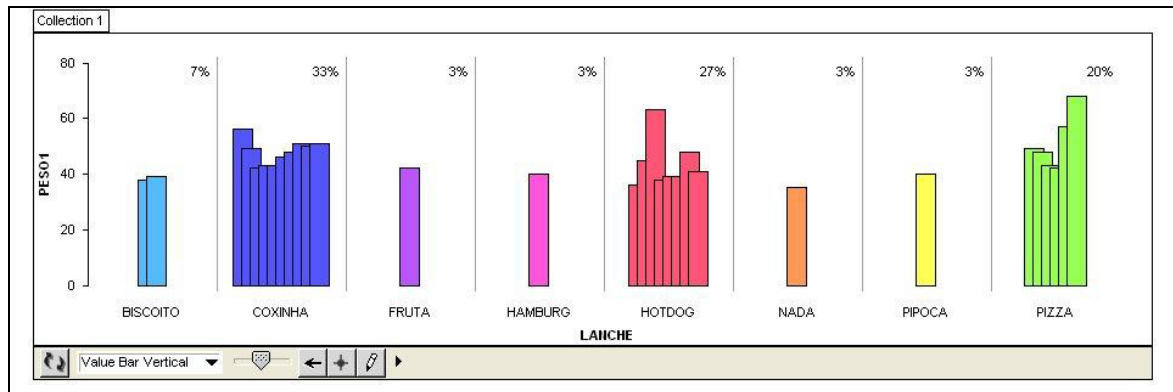
Figure 3. Graph showing the relationship between Snack and Weight1 using the Plot tool.

In their exploration of TinkerPlots tools they could activate the function Count, that makes visible the number of occurrences in the graph. In this case, pair 6 found that "coxinha" had the largest number of occurrences (10) and percentage (33%). They concluded their interpretation writing in a text box: "This graph shows that 33% of people who are overweight are the ones who eat many coxinhas as snack".

Also during the fourth session, pair 6 developed greater skill in the manipulation of the software tools exploring other TinkerPlots functions on their own initiative. For example, while making another plot the students had come across the Reference line tool, but did not fully understand it. They used the Ref tool to have an idea of possible tendencies among the values. Figure 4 shows the graph produced when they were exploring this tool.
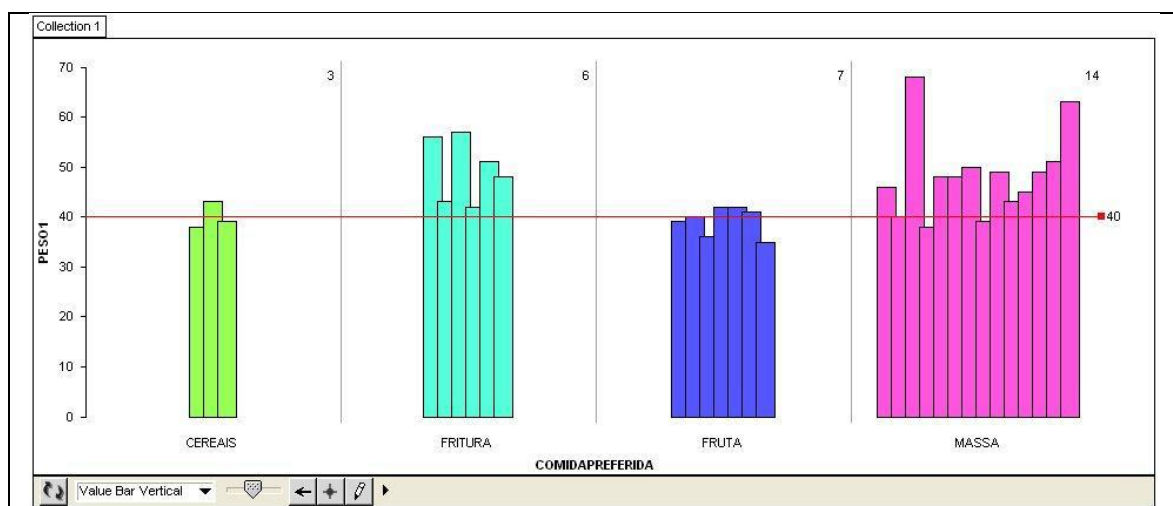

Figure 4. Graph with horizontal reference line produced by pair 6.

They set the weight 40 as the value for those who are keeping their weight within the middle range and located this value using the ref tool. What the students did not realize is that

this average is not the same for all the subjects, because the average weight varies with age, but the use of this tool demonstrates the understanding that pair 6 had developed.

In a text box they explained their interpretation of the graph presented on Figure 4: "People who weight 40 kg are on average and they are the people who prefer to eat fruits and cereals. Most people eat pasta and it can be seen where the greatest amount of weight above the average."

Pair 6 produced other graphs that involved the relationships between different attributes. At the end of the fourth session, pair 6 made a graph (Figure 5) using the attributes Sports (S-practice sports; N - no practice) and Weight (Underweight, Overweight, Average).
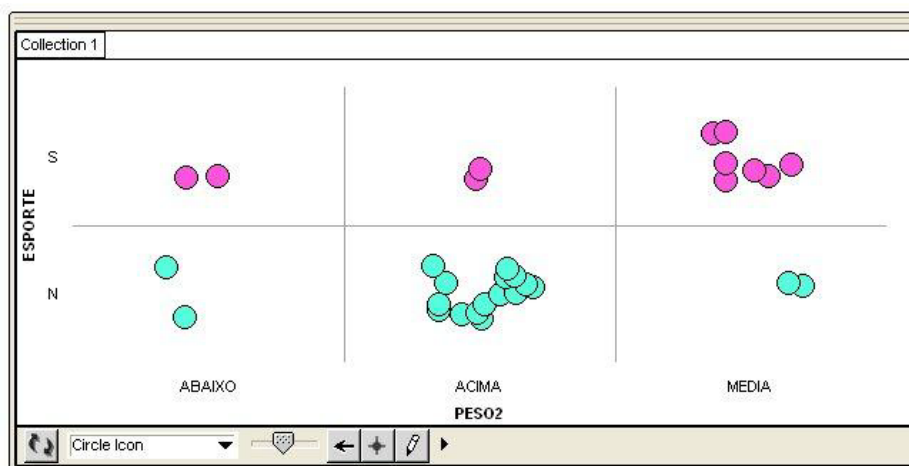

Figure 5. Graph that shows the relationship between Sports and Weight2.

This last graph was also accompanied by a textbox that gave a final remark about the activities that they developed: "Our research found that young people must be feeding poorly due to they eat more pasta and fried food because most of them is with weight above average and also did not practice sport that is a good thing for health." Although their conclusion was not accurate if we consider the concept of average, their conclusion indicates that their exploration of the data provide a reflection with potential to develop other statistical concepts.

Discussion

As discussed earlier, the knowledge of statistics plays a very important role in daily life. Also, computers are increasingly present in daily activities, offering possibilities of tools to mediate the presentation of statistical information. One of the major challenges for statistics

education in schools is to link these dimensions (everyday uses of statistics and computer technology) more explicitly, to make the processes of teaching and learning more effective.

An important element from our analysis is that TinkerPlots supports the construction of different representations that are not usually offered in school contexts to explore data. We argue that this possibility of generating different graphical representations of data also promoted different possibilities for thinking about the data. In addition, the speed with which representations could be produced allowed a better utilization of the available time to focus on interpreting the data displayed, rather than on the construction of graphs. For example, although pair 6 initially focussed their analysis on a single variable (choice of snack), they quickly moved to the more sophisticated approach of considering relationships between variables, considering choice of snack or favourite foods in relation to weight, and then weight in relation to participation in sport. This shift from considering a single attribute to considering relationships between attributes indicates that they are moving beyond simply reading the data, in a way which might mirror the kinds of tasks normally set in the classroom ('Which is the most popular snack?') to making an interpretation of the data which attempts to offer explanations of the emerging patterns. The textboxes they added to their graphs, while not entirely accurate in their content, suggest a growing understanding that the patterns in the graphic display relate to causal explanations in the real world: e.g. "people who are overweight are the ones who eat more pasta and frying. So these foods make people fatter"

The results recorded in the third and fourth sessions suggest that the participation of students in the entire process, from collection to the organization and interpretation of data, helped them to take a more active stance in regard to data analysis. In the third and fourth sessions the participants demonstrated more experience and control in the use of the software tools and, consequently, they presented more complex results. The TinkerPlots tools allowed the participants to manipulate representations in order to explore conjectures about connections between the attributes and thus develop the process of the interpretation of data.

The choice of a context which was familiar and meaningful for students clearly made a considerable contribution to the confidence with which they approached their exploration of the data. However this familiarity also meant that they had expectations about the relationships that would exist between the attributes. There is therefore a sense in which they are partly interpreting what they see in the data, and partly using the data to demonstrate what they expect to see, and this is reflected in the verbal interpretations they make. These often go beyond what can actually be supported by the graph: for example 'So these foods make people fatter'. When using graphs

as a tool in data analysis, it is necessary not only to choose a meaningful display, but also to articulate clearly what the display shows, and to distinguish between describing the relationships and offering explanations for them. The final summary comment made by pair 6 contains a mix of both of these elements. 'They eat more pasta and fried food' and 'most of them is with weight above average and also did not practice sport' are reasonably accurate descriptions of relationships shown in the graphs, but "young people must be feeding poorly" and "that is a good thing for health" go beyond the descriptions to make claims which – though they may be true – are not justified by the data. In everyday situations, familiarity with the context of data may be very helpful in supporting critical interpretation, but it can also lead to conclusions which are based more on prior knowledge or common sense than on the actual data. In pedagogic contexts the choice of tasks, and the questions asked, are crucial in challenging pupils to develop the skills of constructing data-based arguments.

This research provided a starting point which has generated several studies investigating the use of TinkerPlots in other Brazilian educational contexts. Asseker (2011) and Alves (2011) have explored how students and teachers from rural primary schools, who never had contact with computers, could use TinkerPlots to interpret graphs from data presented in this software. Other studies have investigated students' and teachers' understanding of statistical concepts, for example mean (EUGÊNIO; CARVALHO, 2013) and sampling (MARTINS, MONTEIRO, QUEIROZ, 2013).

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