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► **To cite this version:**

Ana Caseiro, João Pedro da Ponte, Cecília Monteiro. Elementary teacher practice in project work involving statistics. CERME 9 - Ninth Congress of the European Society for Research in Mathematics Education, Charles University in Prague, Faculty of Education; ERME, Feb 2015, Prague, Czech Republic. pp.2995-3001. hal-01289721

HAL Id: hal-01289721

<https://hal.science/hal-01289721>

Submitted on 17 Mar 2016

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Elementary teacher practice in project work involving statistics

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This study aimed to analyze the practices of an elementary teacher in conducting project work involving statistics. The study follows a qualitative case study design with data gathered by means of video and audio recording of the teacher's class. The results showed that the teacher followed an exploratory approach with constant reflection during the teaching process. The results also showed a diversity of types of communication and teacher's interventions during the development of the students' projects and a high concern for students' involvement.

Keywords: Teacher practice, statistics, project work, communication.

INTRODUCTION

In Portugal, the 2007 Mathematics Curriculum of Basic Education emphasizes statistics, recognizing that this is a key area in modern society in which students must have a good preparation. To achieve this, students must carry out statistical investigations in school (Groth, 2006). Wild and Pfannkuch (1999) suggest that this is an important way of the learning of statistics.

Teachers' practices are one of the key factors that influence students' learning (Ponte & Serrazina, 2004). So, in order to support the quality of teaching and learning, it is important to develop research on this field (Franke, Kazemi, & Battey, 2007). As project work is about formulating questions and finding information to answer these questions in an engaged and participative way, our research question is to know how do teachers explore students' ideas and promote discussions during this process.

TEACHERS' PRACTICE IN STATISTICS

The concept of teachers' practice is a complex one. O'Donnell and Taylor (2007) emphasize the tasks that teachers use in their classes. Among the various kinds of tasks, project work can be used to foster students' learning as it favours their affective and cognitive involvement. Alarcão (1996) defines six phases in carrying out project work: (i) Choosing significant problems based on the desire to solve them or at least to study ways of solution; (ii) Establishing a plan and outlining ways of doing things, providing resources, planning possible interventions, dividing tasks and managing time; (iii) Contacting with reality, doing data collection through field work; (iv) Organizing and processing data, by comparing, analysing and reflecting on the data; (v) Preparing presentations to others to make known to others the results and the processes experienced; and (vi) Presenting the most significant aspects in a motivating way followed by evaluation of all the work carried out.

The stages of a statistical investigation are similar to those of project work. Problem solving using data is carried out through the investigative cycle (Burgess, 2007). Graham (1987) and Franklin and colleagues

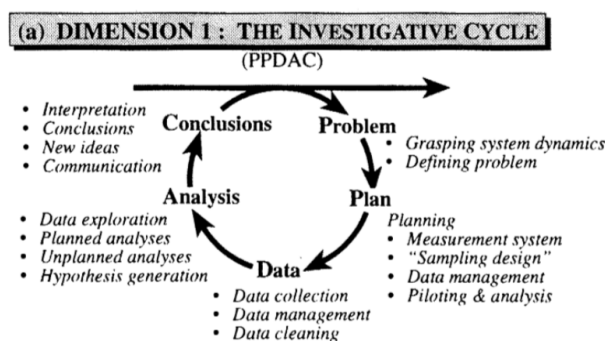


Figure 1: The statistical investigation cycle (Wild & Pfannkuch, 1999)

(2007) refer that a statistical investigation typically involves four steps: asking a question; collecting data; analysing data; and interpreting the results in an organized manner. Wild and Pfannkuch (1999) consider five basic phases of a statistical investigation: choosing the problem, defining a plan, gathering data, analyzing it, and drawing conclusions (Figure 1) and consider three additional key dimensions in statistical work: types of thinking, questioning cycle and provisions.

As Makar and Fielding-Wells (2011) refer, the formulation of the problem is important and should be related to the students' interests. The research question is the starting point of the work and is often overlooked by teachers who end up focusing on the other phases of the cycle. The problem to be investigated should take into account aspects such as the age level and the mathematical development of the students (Ponte, 2001). The second phase of the investigative cycle (plan) is also an important step. According to Shaughnessy (2007), little time is devoted to this phase. Most students are only taught "pre-statistical" topics, being presented with a ready-made problem formulation, plan, and production of data. The next two stages (data collection and analysis) allow students to become familiar with statistical concepts and representations. Finally, in the last phase of the cycle (conclusions) students should be able to verify if their initial questions were answered or whether is necessary to formulate and conduct a new investigation.

Another key aspect of teacher's practice refers to the nature of the classroom communication (Franke, Kazemi, & Battey, 2007). Brendefur and Frykholm (2000) propose a model with four types of communication: (i) uni-directional communication, where the teacher dominates classroom discourse while students listen, so they can reproduce, i.e., in this type of communication the main role belongs to the teacher; (ii) contributive communication, where there is a large number of interactions between actors (teacher and students and among students), although mostly short and where the teacher continues to have a major and dominant role; (iii) reflective communication, where the work carried out is subject to constant reflection, with the students engaging actively in discourse and having freedom to express themselves; and (iv) instructive communication where the teacher systematically draws on students' contributions to improve teaching and learning

Wood (1999) notes the importance of teachers leading students to justify their choices, encouraging everyone to participate in classroom discussions. Based on previous research, Ponte, Mata-Pereira and Quaresma (2013) developed a framework for analyzing the teacher's actions in conducting mathematical discussions, distinguishing four main types of actions: (i) inviting, in which the teacher promotes the initial involvement of students in the discussion; (ii) supporting/guiding, in which the teacher leads the continued participation of students through questions or other interventions; (iii) informing/suggesting, in which the teacher introduces information, providing arguments or validating student responses; and (iv) challenging, in which the teacher seeks that students make generalizations and justifications and question the responses of their colleagues.

METHODOLOGY

The methodology is qualitative and interpretative, following a case study design (Bogdan & Biklen, 1994). We study the case of a grade 4 teacher, Maria (fictitious name) who is 28 years old and has been teaching for 8 years in a private school in Lisbon. After getting her degree as a primary school teacher, Maria strived to deepen her mathematics preparation, making a master's degree in mathematics education and is now enrolled in a doctoral program in mathematics education. In addition, she regularly attends mathematics teachers' professional meetings. In this paper, we analyze her case, as the construction of the other cases is still in progress.

Data collection was carried out from April to June of 2013. Usually, she proposes statistics tasks with situations in which a graph is given and the students had to answer questions about it. The teacher showed some discomfort with this practice, stating that "I would like to do a work like that with other curriculum topics [such as environmental issues] including project work by the students".

The data presented in this paper was gathered through video and audio recording in seven classes taught by Maria. It is presented in the various stages of the investigative cycle of Wild and Pfannkuch (1999) and analyzed according to the types of communication proposed by Brendefur and Frykholm (2000) (uni-directional, contributive, reflective, and instructive communication) and teachers' actions sug-

gested by Ponte, Mata-Pereira and Quaresma (2013) (inviting, supporting/guiding, informing/suggesting and challenging).

The decision to conduct project work with the students was taken on a collaborative group work that was composed by the first author of this paper (hereafter referred to as researcher), Maria and two other grade 3 and 4 teachers. In this session the researcher proposed to discuss the investigative cycle (Wild & Pfannkuch, 1999) and an article about different types of tasks, which included an explanation of project work. After this discussion the teachers decided to use this material to plan their lessons in the frame of project work. For teachers, a key idea was to engage students in their own learning, motivating them through interesting themes, and having them working in small groups. As the teachers had already worked tables and graphs with the students, it was decided that this work would verify the students' knowledge on these representations. Thus, the work was planned, discussed and adjusted together in the teacher collaborative group. The research presented here refers to data collected in Maria's classes in which the researcher assumed the role of participant observer, collaborating with the teacher and interacting with students.

The introduction of the task sought to involve the students in all decisions, especially in deciding how to format their project as a statistical investigation. The only condition imposed was to use quantitative data that could generate statistical representations. The first lesson was intended for proposing the project work, with the teacher seeking to motivate and engaging students. In the second lesson, in a plenary session, all suggestions for topics and study questions were discussed. The following three lessons were reserved for the collection, compilation and processing of data. The sixth lesson aimed to analyse the data and to prepare the presentation and the seventh lesson was designed to the presentation of results to the whole class.

MARIA'S PRACTICE

Introduction of the task and choice of the projects

Maria begun by informing the students that they would develop a project work involving data handling and explaining the different phases that they should

follow. The teacher referred that all the work would be discussed with them. A student asks:

Ana: But we are supposed to do a project work? It takes so long.

Teacher: I do usually tell you what to study? No. Now what we want to do is to make a project work. It takes time, very well, so we have to organize ourselves. Do you know the planning sheet that we usually do? We will also do it to organize our work.

José: You can choose to be a 2 in 1.

Teacher: The theme is of your choice and our concern is that you have to present information in graphical representations.

Thus, the teacher introduced the work seeking to engage students in making decisions about the whole process. This introduction led the students to begin thinking about what they would like to study. The teacher guided the students' work from a perspective of reflection by all (*reflexive communication*), promoting their early involvement in the discourse (*inviting actions*), giving them freedom to express themselves. The challenging nature of this proposal made students to promptly begin participating in the discussion.

The students indicated some topics of interest. The class discussed whether their study made sense to carry out and was of general interest. Many students made suggestions:

Beatriz: We had the idea of making Chinese characters. Are more than ours.

Teacher: Well, are symbols, so it is so hard.

Mafalda: In which countries are different from the letters A, B, C, D, E.

António: It was also turning to ask what they think: think how many letters have alphabet X.

Teacher: But that's just an opinion, an answer.

Mafalda: They could say how many think they have every number of letters and then give the correct answer.

(...)

Teacher: The group of Rome: "What monuments? What are the Roman gods? What is the number of visitors who visited one (or

- more) monument each year?” What they want to know with this project work?
- Leonor: We want to know the number of visitors to monuments per year.
- Ana: Why not make the Greek gods who are over?
- José: Why do not the mean or the mode of the number of visitors?

This dialog shows that students were quite participative, making suggestions for the work of their colleagues. The teacher kept a low level of intervention thus enabling the discourse to be carried out mainly through student-student interactions (*reflexive communication*). All the students proposed themes and questioned their colleagues who received their opinions and questions in a constructive way. The teacher involved all the students in the discussion (through *inviting* actions) and promoted their participation, leading the discourse through *supporting/guiding* actions. In the end nine themes were raised by the students to study: “Monuments and Roman gods”; “Stars and planets”; “Curiosities about the world”; “Sharks”; “Rally Dakar”; “Butterflies”; “The strangest animals in the world”; “Trivia about writers”; and “Professions”.

The plan

The teacher began by referring the importance to design a plan to serve as guide to carry out the subsequent work. With this goal Maria distributed a sheet of paper with a model in order to guide the students to organize the work reinforcing the idea that they should record the questions they wanted to study and begin to think about the representations they intended to build with the data collected to answer each of their questions. The teacher emphasized that they should think about what kind of graph they considered appropriate to use.

A student asked the teacher if they could put some information about the topics under study without doing graphical representations. At this stage, Maria showed a more directive attitude, not allowing a discussion of some aspects of the work she had already decided (as the work plan) or had to decide at the time of the class (such as the introduction of a part writing more information on the subjects). In spite of allowing students to be inquirers, she took a leading role intervening at all times of discussion in the large group (*informing/suggesting* action). In turn, when supporting the small groups in the development of

their work plan, the teacher showed a less interventionist attitude and a more questioning role. She led some groups to think about the issues that their work would address and on the adequate representations concerning the data they would collect. Thus the kind of communication privileged by the teacher was *contributive*, and also, at times, *reflective*.

Data collection

To collect the data they need for the project, some groups decided to search for information in magazines, books and internet, while others decided to construct a questionnaire. The teacher supported the groups in this crucial phase of the investigation cycle, especially two groups that had never done this kind of work. One of these groups decided to study the occupations of parents of students in the class, based on a small questionnaire. The teacher provided some guidance questioning the students about the various aspects they could ask and suggested some elements which students could not be aware:

- Teacher: And no matter whether you are male or female?
- Afonso: But to know that we have to put that “is the father of Monica” or “is the mother of Duarte”.
- Teacher: But that is what is important or you just want to know the occupations of the parents of the class in general?
- António: Oh, we could get to put a cross in the genre, and then write the name of the child.
- Teacher: Oh, good. And they should not put the objective of the questionnaire?
- (...)
- Afonso: We want to know the unemployed.
- Teacher: But knowing what about the unemployed?
- Afonso: The number.
- Teacher: And do you not ask parents what college degrees they have? And you are not interested to see if the parents are working in your area?

This excerpt shows the help that Maria gave to her students who had never built a questionnaire. When she felt that the students could reflect on their issues and could improve by themselves the wording of the questions of their questionnaires, she performed *supporting/guiding* actions. When she realized that the

work was not moving forward she suggested what students should put in the questionnaire, with *informing/suggesting* actions. In this phase the teacher was both a guide and a reflective participant privileging *reflective communication*.

Data analysis

The students had to process and analyze the data (organizing it in tables in Excel and then making a graphical representation). The teacher circulated by the several groups in order to support their work and to assist in solving their questions. When checking that the question was not just specific of a group or referred to aspects already worked out and discussed in class, Maria conducted a whole class discussion:

Teacher: Now stop a little because now I want to discuss something with you. All of you can help that group studying butterflies... The group of butterflies discovered several species of butterflies and so now they want to make a bar chart and want to put here [in the x axis] the name of the butterfly and then here [y axis] heights. And my question is: this is a bar chart?

Gonçalo: It's not because it has no frequencies.

Teacher: And what is the frequency?

Gonçalo: It was for example if they where [x axis] had 2m to 5m. Imagine that these two [butterflies] one has 3m and another has 4m, then both were in that range and so it was a bar chart with frequency.

Teacher: I do not know if it is okay but what he is saying is that maybe it would be a good idea to arrange size ranges. (...) You must have what the Gonçalo said: frequencies, how often it happens, the number of times, the number of butterflies with 20cm (...).

In this example the teacher strived to involve the entire class in discussing an aspect of interest to several groups, the construction of a bar chart. She took the opportunity to explain students about the concept of bar graph, stressing the distinction between variable and frequency. The teacher assumed the central role of the classroom discourse by systematizing some knowledge of statistical representations, and the role of students was to listen to her explanations. At this stage of the investigative cycle the teacher tended to

have a *uni-directional and contributive communication*, and her main actions where *informing/suggesting* and *supporting/guiding* students.

Conclusions and presentations of projects' results

Due to the end of the school year students ended up not having much time to draw conclusions from the data analysis that have made, and for preparing presentations. Maria suggested that all groups prepared a presentation with the data that they had already collected and analyzed so far. Thus some studies only presented a brief analysis of the data, and the teacher questioned some aspects to lead the students in reaching some conclusions. For example, the group that conducted a study on the Rally Dakar elaborated the graph (Figure 2) that displays information about the bikes used by the winners between 1979 and 2011. The students were asked by the teacher:

Teacher: So if we want to win you have to be with a ktm?

Miguel: The ktm is usually that almost all winners use. It is almost always the ktm wins.

Despite the short time available for this phase was still possible for the teacher to discuss some important aspects with their students, with a great student's involvement in the discussion, having the possibility to express themselves and to question the colleagues. At this stage of the investigative cycle, the role of the teacher became more questioning and challenging providing the formulation of conjectures by students.

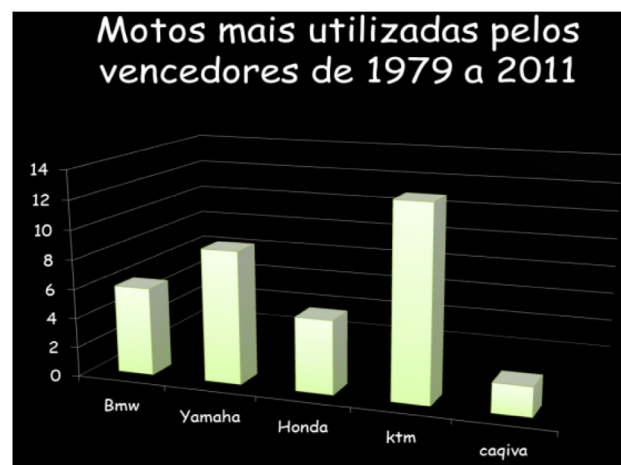


Figure 2: Graph constructed by the group, whose project was on the Rally Dakar

FINAL REMARKS

In the introduction of the task and in the phases of *problem*, *data* and *conclusions* of the investigation cycle (Wild & Pfannkuch, 1999) the teacher encouraged the students to get involved in the classroom discourse with complete freedom of expression. The communication developed along these phases may be seen as *reflective communication*. In the reflection phase of the *conclusions* the communication promoted by the teacher tended towards *instructive communication*. In the phase *plan*, Maria tended to promote *contributive communication*, notably in the whole class discussions in which she allowed small interactions between the students but made many validations and kept a major role in the decisions. This aspect may be due to the fact that she did not feel safe in carrying out project work involving statistics, as it was the first time she was doing it in her class. In turn, during small group discussions, the teacher enabled the students to discuss the issues and representations they wanted to do, which demonstrates *reflexive communication*. In the *analysis* phase, Maria tended to dominate the discourse explaining and transmitting knowledge, assuming a dominant role in the classroom discourse. Sometimes she put some closed questions and gave direct responses, which seems in line with *uni-directional communication* and *contributive communication*. This may be due to the fact that she felt the need to address some statistical aspects with the class that had already been worked before, as she just realized that such aspects had not been understood by students.

In terms of the actions of the teacher, they varied depending on the progress of the class and the development of the projects. In the introduction of the task these actions were mainly *inviting* students to participate, which also happened in the choice of the *problem*. At this stage, Maria also took *supporting/guiding* actions in the discussions. During the phases *plan*, *data* and *analysis*, the teacher tended to *informing/suggesting* actions, which during *data* and *analysis* are complemented by *supporting/guiding* actions. Finally, the phase of the *conclusions* the teacher tended to *challenging* actions, seeking to lead her students to go further

Finally, the choice of project work methodology shows that the teacher follows an exploratory teaching approach. In this approach the teacher does not have full control, to the extent that, for example, she cannot

predict what topics and issues the students will select to study and how they will want collect the data. In summary, and responding to the research question, how do teachers explore students' ideas and promote discussions during the project work process, we see that the teacher enabled students to express themselves, using mostly *supporting/guiding* actions and following a *reflexive* communication.

ACKNOWLEDGEMENT

This work is financed by national funds through FCT – Fundação para a Ciência e Tecnologia, under the project Developing Statistical Literacy (contract PTDC/CPECED/117933/2010).

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