SUSTAINABLE DEVELOPMENT GOALS: A STATISTICAL LITERACY JOURNEY

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This work appears as a contribution to the approach of statistical literacy using a very important theme for the planet and for humanity at the present time, the Sustainable Development Goals for 2030 defined by the United Nations. These goals require action on a global scale by governments, companies and civil society to eradicate poverty and create a life with dignity and opportunities for all, within the limits of the planet. The works developed by several teachers over several years and which, in one way or another, meet these objectives are presented. Having literate citizens in statistical terms meets the goals for 2030 and also involves the whole of society, as it includes the necessary skills to understand the statistical information that we face every day.

INTRODUCTION

The Sustainable Development Goals (SDGs) define the United Nations' global priorities and aspirations for 2030 and require action on a global scale by governments, businesses and civil society to eradicate poverty and create a life with dignity and opportunities for all, within the limits of the planet. It is an ambitious agenda that should be implemented in the until 2030, it is composed of 17 objectives and will serve as a guiding guide for world development. These objectives highlight people, human rights and the response to social inequalities, as well as encompassing decisive issues such as peace, security and climate change. This agenda is the result of the joint work of governments and citizens around the world, which aims to create a new global model to end poverty, promote prosperity and well-being for all, protect the environment and combat climate change (Governo de Portugal, 2017). To what extent are these SDGs related to statistical literacy? How can statistical literacy contribute to being involved in the global priorities and aspirations for 2030 established under the auspices of the UN?

For Rees (1996) "The ecological footprint of any specified population is defined as the total area of productive land and water required on a continuous basis to produce all the resources consumed, and to assimilate all the wastes produced by that population, wherever on Earth that land is located." So, in a quick search on the internet about the ecological footprint, it is necessary to be a literate citizen to understand them, since many figures and texts USE statistical concepts, as shown in Figure 1.

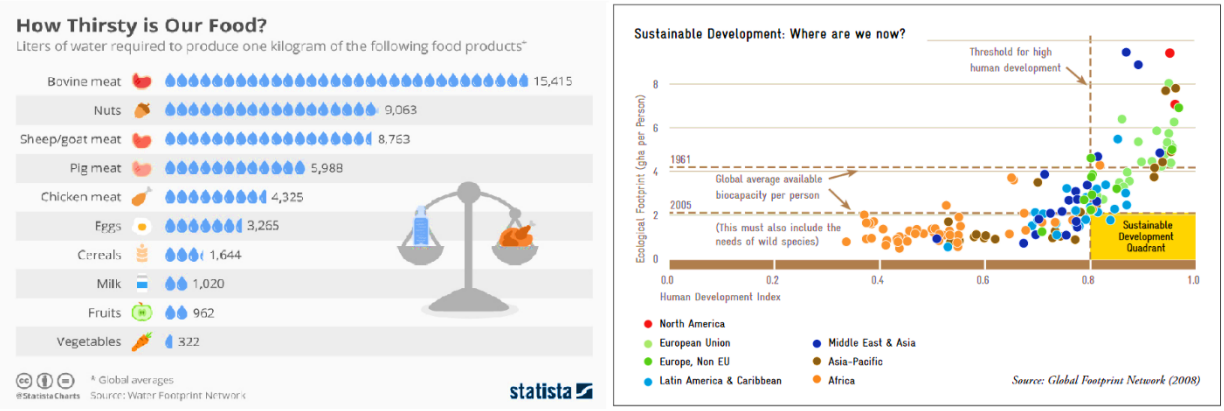

Figure 1. Examples of statistical concepts involved in reading the graphs (right Amend, et al., 2010, p. 72, "Global average available biocapacity per person"; left "Liters of water required to produce one kilogram of the following products*Global averages"[1])

[1] Retrieved from https://www.statista.com/chart/9483/how-thirsty-is-our-food/

In this paper we give some examples of how it is possible to link statistical literacy with the sustainable development goals because, within the limits of the planet, action on a global scale must involve citizens, that is, civil society to eradicate poverty and create a life with dignity and opportunities for all. This interconnection is possible using real, everyday data and can be carried out at all levels of education.

LITERACY, INVESTIGATIVE CYCLE AND PROJECT WORK

Richmond, Robinson and Sachs-Israel (2008, p. 18) quote UNESCO definition of literacy as '(…) the ability to identify, understand, interpret, create, communicate and compute, (…) involves a continuum of learning in enabling individuals to achieve his or her goals, develop his or her knowledge and potential and participate fully in community and wider society'." Statistical literacy includes the basic skills necessary to understand statistical information (Ben-Zvi & Garfield, 2004). They include the ability to organize data, build and display tables, and work with different representations of data. A statistical literate citizen needs to understand concepts, vocabulary and symbols, and that also includes understanding probability as a measure of uncertainty. In addition, Ben-Zvi and Garfield (2004) refer to statistical reasoning – the way of reasoning with statistical ideas and making sense of statistical information – and statistical thinking – which encompasses the understanding of statistical investigations of why and how they are carried out and the concept of data variability must always be kept in mind, as well as the appropriate methods for analyzing them.

In several countries the teaching of the concepts of probability and statistics, within the Mathematics, is part of the official programs with greater or lesser importance and, sometimes, suggesting an active education based on contextualized situations that representative of those concepts' meanings. If the student has a central role in the learning process, he has an active role in building his knowledge, discovering and solving problems, building and deconstructing personal meanings. So, "Instructors who switch to active learning and follow those recommendations almost always say that their classes are much livelier and more enjoyable and the quality of learning goes up (…)" (Felder, & Brent, 2009). Wild and Pfannkuch (1998) cite curiosity, skepticism, openness, a predisposition to deepen knowledge and involvement of the students. In statistics, the investigative cycle encompasses the problem, the plan, the data, the analysis and the conclusions. In this cycle, for example, in planning, the type of sampling stands out and, in the analysis, the use of appropriate descriptive and inferential statistics. Therefore, it makes perfect sense to use the methodology of the project work that leads students to solve a statistical problem with the use of "their own" data. The stages of the methodology of the project work arise from the identification/formulation of the problem; research/production; presentation and final evaluation. This methodology allows students to use their own knowledge, valuing the construction of thought processes, promoting their critical sense and their autonomy. Using project work, the group changes of ideas and assigns each of them a role. In addition, they also be involved in the 21st century skills development: to think critically, apply knowledge to new situations, analyze information, understand new ideas, communicate, collaborate, solve problems, make decisions (Wrahatnolo, 2018). The project work is appropriate to approach with the students the investigative cycle of statistics and its stages can be analyzed together: the identification/formulation of the problem in parallel with the problem of the investigative cycle in statistics; research/production in parallel with the plan, data and analysis of the investigative cycle; and the presentation and final evaluation in parallel with the analysis and conclusions of this cycle. The parallelism between the project work methodology and that of the statistical investigative cycle brings students closer to problem solving in situations very similar to real situations (e.g., Nascimento & Martins, 2008). In this way, the statistical literacy journey involving the ecological footprint (EF) study also addresses sustainability and can meet the SDGs.

WORKS INVOLVING THE ECOLOGICAL FOOTPRINT

Is it reasonable to save that much?(Master Student)

In 2004/05 school year, an episode was promoted in a training class for a vocational program with a mathematical syllabus similar to that of the 1st secondary year (ages 16). In the "Mathematics and Reality" course, teacher decided to dedicate a January class (90 minutes) to raise students' awareness of the ease with which situations are encountered in everyday life when we use statistics without realizing it. The teacher adapted a commercial and prepared some questions (Figure 2) and as a result of this work, although the students did not highlight what calculations they were doing, and although

implicitly, in justifying the number of dishes to be washed per day, students have already considered the concept of dispersion. In addition, students were able to discuss/express/write their opinion about the absurdity of the ad, invoking, again, the concept of dispersion.

1. De aco estima qua de F... em
2. Achas q
3. Se relat estimativa opinião?

1.In the commercial you saw, estimate how many days 1 litre of F… will last in your house.
2. Do you think that that estimate makes sense in daily life?
3. If you show and discuss that estimate to your mother, you think that she will agree?

Figure 2. Task of the episode in the classroom (translated from Nascimento and Neves, 2005)

An approach using water bills

In the 2006/2007 school year, statistics in vocational education was addressed using water bills. The work covered a total of four sessions, each with four hours and was adapted to the Portuguese case from Cazorla and Santana (2006). The tasks (Figure 3 on the left), their goals (Figure 3 on the right) and in addition to the digital presentations, the students built a poster with the "reading" of a water bill (Coelho, 2007).

Table 1. Tasks, and its goals (translated from Coelho, 2007, pp.36-37)

Tasks	Contents and concepts
1	• Internet search for water information • Data collection
2	• Cubic meters to liters conversion • Interpretation of water bills • Real-life problem solving
3	Statistics related to the water consumption: • Arithmetic average • Annual consumption • Annual consumption per capita • Average monthly consumption • Average daily consumption • Average daily consumption per capita Graphical representations • Bar charts Introduction to variability • Amplitude of consumption values • Uniform consumption • Variable consumption
4	Complete the project work

Goals	Tasks			
	1	2	3	4
Define the problem to study	•	•	•	•
Perform data collection	•	•	•	•
Organize data through calculation of statistical measures, its interpretation		•	•	
Select most appropriate graphic(s) representation(s) and interpret them critically			•	•
Develop a critical sense of the way how information is presented	•	•	•	•
Communicate reasoning and/or arguments mathematicians in oral and/or written form		•	•	•
Complete the project work				•

Ecological footprint in the 3rd cycle of basic education (Master Student)

In addressing the topics of data analysis (OTD Portuguese acronym, the program concepts related to statistics) of the 7th year mathematics of the 3rd Cycle of Portuguese Basic Education (3C, age 12), the EF survey (S) was done, adapted from of the survey available on internet. When preparing the data analysis of the EFS, it was divided in: footprint of housing, footprint of food, footprint of transport and mobility, footprint of waste and footprint of consumption; global footprints of the 7th, 8th and 9th grade (ages 12-14) of the 3C. The surveys were completed by all students of the school in the 1st class of Mathematics at the beginning of the 2009/2010 and OTD was approached in a class of the 7th year of the 3C (Raposo, 2010). During eight classes the eight themes were analyzed each by a group of three students. With regard to content knowledge in OTD, the teacher was of the opinion that most of the students demonstrated that they had it and, as a general rule, knew how to apply that knowledge and is able to apply it, in their day-to-day activities. They were able to organize and analyze the information expressed in different ways (tables, graphs, graphs of extremes and quartiles), to compute and interpret the measures of central tendency and dispersion of a data set; and also, to express their opinions (Raposo, 2010). The main difficulty of the students was text of the tasks' interpretation. Most

of the requests they made to the teacher were to help them understand the tasks. The students also felt many difficulties to make themselves understood among them during the tasks, they lacked the appropriate terms (in Portuguese and related to statistics) to express themselves (Raposo, 2010). On the other hand, the computer and the internet connection were essential in approaching the theme: search on the internet, to build graphs, to compute measures of central tendency and dispersion, to write the answers to the questions and to elaborate the digital presentation (Raposo, 2010). From her field notes, the teacher concluded that many students learned more with the help of their group colleagues than if they had worked individually (Raposo, 2010). The tasks involved the students more than the traditional exercises and problems out of context and invented. In summary: They allowed students to become enthusiastic about Mathematics, get involved in OTD and also learn to use computers in Mathematics class (Raposo, Nascimento, Estrada & Martins, 2013). The tasks used in the work of Raposo et al. (2013) were presented in a conference paper, so that they can be used by other teachers and when relating them to the investigative cycle of statistics.

Project work in higher education, including the theme of the ecological footprint (Course Degree Students)

Even before the reforms introduced by the Bologna Process, the project work was already used in higher education in order to broaden the students' perspective in relation to the practical applications of statistical concepts (e.g., Nascimento & Martins, 2008). In this way, and using the investigative cycle of statistics, in the courses a theme was used, questions are formulated, a survey is built on the theme, answers are collected, data is coded, analyzed, and is interpreted in relation to the questions asked. In all this project work, emphasis is placed on the writing reports issues and in the results presentation (written and oral) so that everyone can understand it (e.g., Batanero & Díaz, 2004). The project work was more or less demanding depending on the students' level (only descriptive statistics or a with some inferential aspects, e.g., chi-squared independency tests and hypothesis tests). And the use of technology (spreadsheets, statistical software, tools available on the internet, e.g., Google Drive or Moodle) is already mandatory for students to carry their work (e.g., Raposo et al., 2013)

In the 2nd semester of 2007/2008, the ecological footprint theme and EFS was introduced with reports (summary, introduction, research questions, data description and analysis, discussion and references) and using the spreadsheet in Applied Biostatistics for Biology degree and in Statistical Methods in the Forestry degree. Thus, the stages of the project were: search for the EFS, analyze the questions, propose an appropriate question to include, collect the data (among students, friends, etc., therefore a convenience sample), code the variables, build the database, analyze them using the "Data Analysis" module of the spreadsheet, appropriate graphs, discussing and concluding. In these reports, the students also presented suggestions for measures to be taken in order to decrease the EF found.

In the 2nd semester of 2010/2011, the theme was taken up again in the same degrees, but the final product became a poster (influenced by the ISLP international posters competition, Figure 4). In this academic year, the students' efforts turned out to be greater, as their work was summarized in one or two A3 sheets, in a digital poster format. In the final posters the oral presentation of the students was also made and weighted in the final grade with 20%.

The students perceived the EFS to be easy to answer relating to their consumption behaviors. Nevertheless, some problems arose in some of the questions. For instance, in this northeastern part of Portugal many homes use either wood and gas as fuel to different heater systems and if they choose both of them the EF would be very big. As in Collins Galli, Patrizi, and Pulselli (2018) also referred that the EF calculator did not consider some changes of students' habits such as diminishing the purchase of paper (e.g., books, newspapers) but not taken in consideration that the energy consumption will increase, since reading will be done using the computers, tablets, and so on.

Figure 4. Examples of two posters from 2010/2011

In all the project works the students group work was mandatory, sometimes outside class hours, other times combining class hours with work outside the classroom (tutorial guidance) and it was done along all semester in order to illustrate the subjects taught so the groups could see if they were able to apply them (or not) to their project work (and why).

Finally, in the first semester of 2019/2020 the project work was about the e-waste. "Technological advances are coming at us at such a speed that a lot of electronic devices that still work fine are the ones considered obsolete. If a product is electronically powered and someone thinks they can create a better version, that contributes to e-waste. And we care about this because unwanted electronic devices have been filling landfills across the globe, for years. What to do with the devices we dispose of, that is, with electrical and electronic waste (e-waste)? The survey aims to assess the awareness that engineering students have on the topic of electrical and electronic waste." – was at the survey text heading. In the beginning students were amazed with e-waste aspects and consequences the found in the internet but the statistical posters were poor, since they leave them to the semester's end and then they had a lot of work.

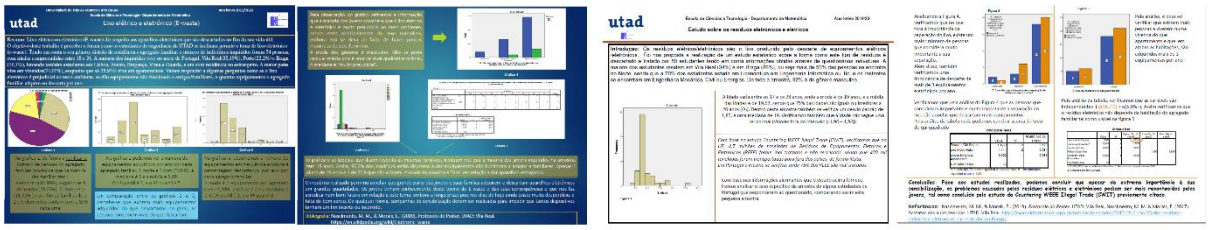

Figure 5. Examples of two posters from 2019/20

CONCLUSION

This work is as a contribution to the approach of statistical literacy using the important theme for the planet and for humanity at the present time, the Sustainable Development Goals for 2030 defined by the United Nations. So, through practical examples they develop their knowledge and potential and, thus, participate fully in their community, country and to the society in general (Richmond, Robinson and Sachs-Israel, 2008).

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