



A PRACTICAL APPROACH TO STATISTICS THROUGH SRP

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ABSTRACT

The paper explains the design and the first part of the implementation of a project within the subject of Statistics with first year students in a Bachelor's degree in ICT Systems Engineering in Manresa School of Engineering, part of the Universitat Politècnica de Catalunya. We use the methodology of *study and research paths* within the Anthropological Theory of the Didactic and under the paradigm of "Questioning the world".

The project topic is the "water". The experience is linked to a broader UPC-driven project, called *AquaeSTEAM*, based on questions to spark new ideas and science

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and technology solutions to solve water-related problems. After narrowing down the issue to concrete problematic questions, the students analyse data published in IDESCAT, the Statistical Institute of Catalonia, related to water consumption, both domestic and industrial, factors related to climate change, such as temperature and pluviometry, among others, and will also carry out a survey to link all these studies with the water footprint.

The implementation sheds light on the conditions needed to integrate project-based proposals in the traditional organisation of the subject. It also provides information about the changes that may take place to facilitate the integration, in both the subject's content and instructional structure (lectures and tutorials). The conditions required are then compared with other experiences of study and research paths in engineering education carried out these past years in the Anthropological Theory of the Didactic.

1 INTRODUCTION

This paper presents an inquiry-based instructional proposal called *study and research path* (SRP) we implemented this academic year 2021-22 in the subject of Statistics of the bachelor's degree in ICT Systems Engineering in Manresa School of Engineering, one of the schools of the Universitat Politècnica de Catalunya (UPC). Like other European universities, UPC has been going through a methodological transformation in education for some years, especially from the adoption of a competence-based curriculum within the European Higher Education Area, but it is the first time an SRP is implemented at this school although some other project-based activities had been carried out before in the same subject, by one of the authors [1]. The analysis of an experience at secondary school was presented and discussed at CERME Conference this 2022 [2].

Study and research paths belong to the theoretical framework of the Anthropological Theory of the Didactic and respond to the pedagogical paradigm of *questioning the world* introduced by Chevallard [3]. In contrast with the prevailing paradigm of *visiting works* that gives priority to the works of knowledge students must learn, in this new paradigm, questions go first, and knowledge works are only used and studied to elaborate answers to the questions. An SRP begins with a generating question that is given to the students who address it under the guidance of the teacher(s). In the process of answering the generating question, new derived questions arise that the study community (made of teachers and students) need to answer to develop the inquiry. Addressing the derived questions requires searching already available information (knowledge works, empirical data, etc.) and studying it. It also requires testing it and developing the available resources to elaborate the final answer.

Barquero et al. [4], present different modalities of SRPs implemented in university education during the past 15 years and illustrate different strategies for integrating them into traditional course organisations. They also analyse the effects produced by a change in the generating question within a given course and modality. In terms of

the share of responsibilities between the teacher and the students – the *didactic contract* –, these authors show the importance of introducing an external instance (like a fictitious client or consultant) that raises the generating question and to whom the final answer is addressed. This strategy supports the new didactic contract that needs to be established and the means used to validate the final answer. It is the “client” and not the teacher who determines what a good final answer is according to the initial demands. Therefore, the validation criteria can be separated from the pure instructional ones.

This contribution presents an SRP that introduces a new modality in what concerns the choice of the generating question. Instead of being proposed by the teacher or by an external instance, it is the students who are asked to choose it according to their interests in a fixed theme: the water. This new option has given rise to special features in the development and management of this SRP and also in the students’ learning, which will be listed in the last section. It will be interesting to analyse them from the ATD point of view in upcoming works. To get there, section 2 summarizes the design and the first steps of the SRP and section 3 discusses the development of the main question of the SRP.

2 DESIGN AND FIRST STAGE OF THE SRP

2.1 Setting the context

This SRP design and implementation were subject to some conditions found in the school. The subject of Statistics is taught in the first year and second semester of the bachelor’s degree in ICT Systems Engineering at Manresa School of Engineering, at UPC. The group consists of 40 students and the subject is developed in two weekly sessions of two hours each, one session for the full group and the other session for half of the group, at the computers lab, where the SRP has been developed for several weeks. The syllabus, exercises list, and lab questions, and assessment criteria are shared with other degrees where Statistics is taught at the same time. Because of that, the SRP could not play a primary role in the subject, and it had to share space with traditional lectures and tutorials. However, the assessment was slightly modified to give the SRP a weigh of 20% divided into a final report (10%) and a poster with an oral exposition (10%). Nevertheless, it is expected that the benefits provided by the SRP will indirectly influence positively the percentage coming from other evaluation activities. In addition, the subject has been assigned the evaluation of the competence of autonomous work.

From the previous experiences and the competences assigned to this subject, two aspects were taken into account: empowering students’ autonomy and promoting learning around quality and data management.

Unlike other SRPs previously implemented at the university level, this one does not start with a main question proposed by the teacher. Here students were asked to propose their own questions in the framework of a general topic: the “water”. In this way, the experience is linked to the project AquaeSTEAM and focuses on the role of

water in our daily lives and its relation to science and technology. AquaeSTEAM is a project co-funded by FECYT to promote scientific culture and to build up resources to be used at all educational levels with an interdisciplinary approach in relation to the Sustainable Development Goals (SDG) of the 2030 Agenda for Sustainable Development, approved by the United Nations on 2015. The project promotes the habit of questioning the world, proposing several questions and suggesting different approaches to each one.

2.2 Brief description of the first part of the SRP

The first activity carried out in class gave the students an insight into what they were going to study in the subject. It also illustrated the process followed from the consideration of an initial question until finding a final answer. It is an activity in which each student receives a dice and they have to decide whether it is tricked or not. In this one-hour activity, the students start gathering data, they see how to organise it, the main points of descriptive statistical analysis, a bit of probability and the beginnings of statistic inference [5].

After this activity, the SRP was presented to the students. Instead of the teacher presenting a generating question, which is a key element to starting an SRP [6], this responsibility was passed on to the students who had to think about a question they would be interested in answering around the given topic. Students organised themselves in small groups.

The first step for each group was to start doing some research and gathering information to formulate a question. The second step was to link questions with data and define the aim of the study and which variables are going to be analysed. Some derived questions showed up and students were invited to build up a question and answer map, which will be completed throughout the project. Figure 1 includes an example from one of the groups illustrating the structure of some derived questions.

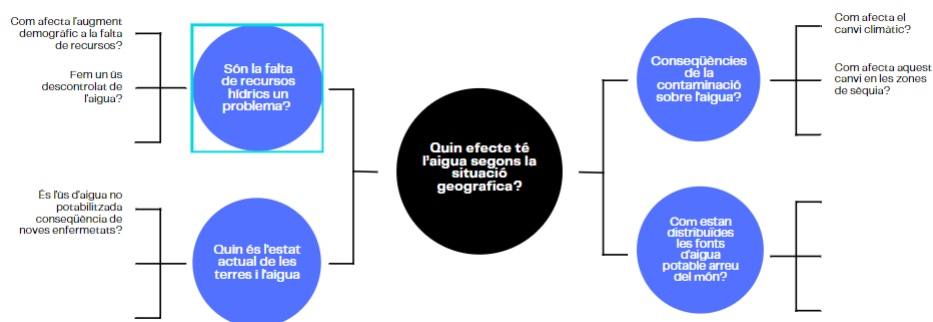


Fig. 1. Questions map of a group of students

Before beginning to look for any answer, a third step was required: the analysis of the study proposal, namely the viability of the study, by analysing the kind and quality of the data provided. This is one aspect that very often remains in the shadow in educational contexts. The study community, composed of the students and the teacher, was in charge of that during several sessions. Examples and exercises on descriptive statistics were discussed, and time was devoted to discussion and peer

reviews. More details on this part are described in [7]. Questionnaires were used to make the application of a rubric easier and also to gather information from the point of view of didactic research. Results will be discussed in section 4.

3 DEVELOPMENT OF THE MAIN QUESTION

Since the data provided by the students were not in most cases easily “studiable” and to begin with all the questions in parallel will be too wide, the teacher looked for common ground to focus the work on a common issue: water consumption. Both domestic and industrial consumption was going to be considered, with data provided by official sources. In future stages of the SRP, each group of students could channel these first findings toward their initial question and could help them narrow it down.

Each group chose a region of Catalonia for their study, keeping a relationship with their initial question, and checked what data was available in the IDESCAT (Institute of Statistics of Catalonia) for each municipality, which could be related to water consumption. It was agreed to study the following variables: number of inhabitants, sex, age ranges, domestic water consumption, industrial water consumption, surface, price of water, unemployment, number of inhabitants enrolled in Social Security, sports facilities, touristic accommodations, home building and municipal waste. Eleven regions were studied: Bages, Berguedà (as central regions), Vallès Occidental, Baix Llobregat and Barcelonès (as metropolitan regions), La Cerdanya and Vall d’Aran (as northern mountainous regions), Ribera d’Ebre and Baix Ebre (as southern regions), La Selva (as north-coastal region) and Pla d’Urgell (as rural region). Each group carried out a descriptive statistical analysis and checked the correlation between variables.

Some of the results of this analysis can be seen in the following graphics and tables. The analysis was not reduced to usual histograms or pie charts, but students experimented with other graphics. For example, Figure 2 shows two charts. On the left, the box plot is associated with the various variables, allowing us to compare what it is telling for each. On the right, it is illustrated how the same group of students experimented with sophisticated graphs to show the comparison of values of the variables for the different municipalities in the region.

Concerning the study of correlation, Table 1 shows the summary of the correlation coefficients between domestic or industrial water consumption and the different variables, carried out by another group of students.

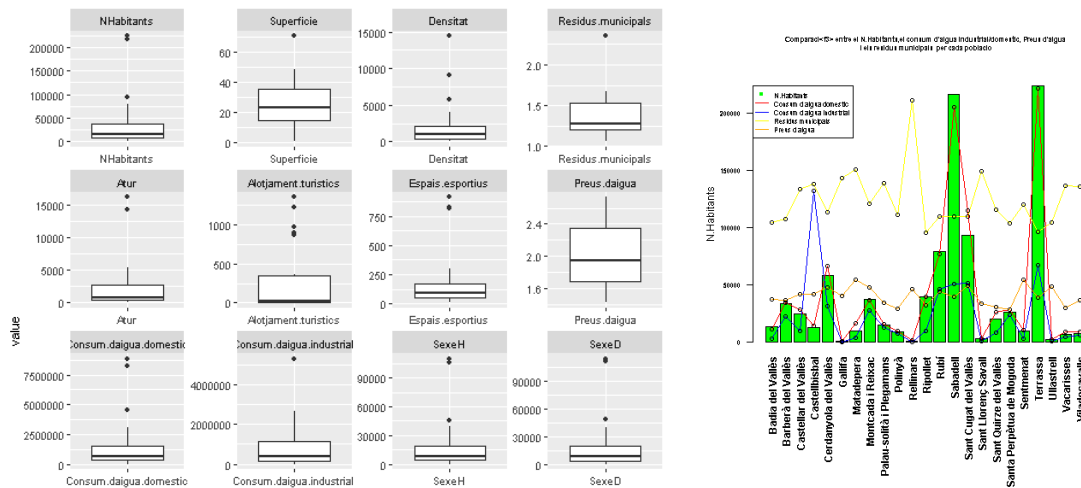


Fig. 2. Plot boxes for several variables and simultaneous comparison of variables by municipality (Vallès Occidental)

Table 1. Coefficients of linear correlation (Berguedà)

Variable	Coefficient of linear correlation (r)	
	Domestic consumption	Industrial consumption
Inhabitants	0.9944899	0.7686851
Surface (km2)	-0.1910381	-0.04068739
Price of the water (€/m3)	0.3382914	0.3876078
Unemployment (mean of people)	0.9941054	0.74788869
No. of inhabitants enrolled in Social Security	0.9924128	0.77418386
Sports facilities	0.8695737	0.68088891
Touristic accommodation	0.6494041	0.44081208
Home building	0.9724515	0.69912799
Municipal waste (tones)	0.9960272	0.75759798

After sharing this part of the study, the students have the chance to carry on with their first proposal of the SRP, in case it was good enough to do so or have the chance to change the first approach, set a new main question to be answered. In the first case, they have the chance to merge all their findings until that moment (previous research and first proposal, and analysis of the region about water consumption). In the table below, it is shown the first proposed generating question, the region afterwards studied and the definitive generating question of some groups of students. The question in green represents the question that has been maintained, the questions in yellow represent the questions that have been kept but

have been narrowed down and the cases in red represent the questions that have been totally changed.

Table 2. Generating question proposed – Region studied – Final question

<i>FIRST QUESTION</i>	<i>WATER CONSUMPTION IN SPECIFIC REGION</i>	<i>FINAL QUESTION</i>
<i>Has the 2020 confinement affected the level of water consumption in Barcelona?</i>	<i>El Barcelonès</i>	<i>Has the 2020 confinement affected the level of water consumption in Barcelona?</i>
<i>How much water do nuclear plants consume?</i>	<i>La Ribera d'Ebre</i>	<i>How much water does Ascó nuclear plant consume?</i>
<i>How does water brought by rivers in Catalonia vary?</i>	<i>El Baix Llobregat</i>	<i>How does water brought by river Llobregat vary?</i>
<i>What effects has society had in water?</i>	<i>El Berguedà</i>	<i>Do the political views of the inhabitants of El Berguedà affect on water consumption?</i>
<i>Is it possible to maintain a swimming-pool efficiently not letting fungus grow?</i>	<i>La Selva</i>	<i>What is the water footprint of the technology of first-year ICT Systems students?</i>

The following stage will be reported and analysed in upcoming works.

4 ANALYSIS AND FINDINGS ON THE FIRST STAGE OF IMPLEMENTED SRP

Questions proposed by students were creative, and the map of derived questions showed their interest in water issues and SDG in general, part of the goals of this project. The main difficulty was to link the questions with suitable data, as their knowledge about how to manage data was limited, and in some sense lower than what was expected. However, it led to going deeper into that part, usually disregarded. Some sessions on data management and analysis were introduced, complemented by a peer reviews activity that increases learning opportunities for the students.

The perception of students about their learning process was collected through a questionnaire, with the aim they could see where the question is driving them. When asked about the limitations of their initial proposals, they confirmed our analysis with answers such as: “Improper and/or unnecessary data were provided” or “The main question was too wide”. When asked about what they learnt from review activity (own one, peer and teacher reviews), they also wrote explicit answers such as: “Different approaches and how the others have used the data”, “To carry out a good descriptive analysis and to select proper data”, “To check if the revision and our data were correct”, “Possible mistakes we hadn’t taken into account previously”, “Possible relations between variables”, “Inspiration for our project”, “Aspects the others can improve and so can we”.

From the analysis of the development of the generating question some interesting features related to autonomous work and critical sense could be listed too.

- Students used more complex graphics, other than the usual histograms or pie charts, and experimented with them for several variables.
- Some new questions appeared due to the use of real data, and students argue: *“When grouping the data in classes (number of inhabitants), some criteria cannot be met. Most of the municipalities in “El Berguedà” have less than 1000 inhabitants, but the capital city has a lot more (16.682) and we do not know how to set the classes: either we make more than 20 classes or the class (0,1000] contains more the 30% of the data.”*
- Students also experimented on software further than the presented option: *“We have decided to calculate the classes using R and not R Commander. It is more efficient since it generates a table with two columns: one with all the classes and the other one with the absolute frequency of each of them.”*

Experience is still in progress and this “in vivo” analysis was very interesting and fruitful because it allowed feedback on the same experience.

An a posteriori analysis will be conducted from the point of view of the ATD. However, since it is the first SRP experience at UPC, it makes sense to sketch some comments related to the first phases. Following Barquero et al. [4], when the generating question “is taken seriously”, that is, when the teacher lets the question lead the inquiry, she does not know the paths that will be followed and assumes the role of a guide who helps students progress in their study, organizes the sharing of results, orients the search of new information, etc. Since the question is open, the teacher does not know the answer – and many times there is no unique answer to the question – and the decisions made during the SRP (by the teacher and the students) are not based on pedagogical criteria – to better learn such or such topic – but are subordinated to the sake of finding an answer to the generating question. In the case here considered, students were requested to formulate their own questions related to the topic. A logical consequence is the increase of complexity for the teacher to guide several parallel inquiries at the same time.

In terms of the didactic contract, this choice produces a change in two directions. On the students’ side, it increases their responsibility with delimiting the question to address and finding criteria for it, which entails the learning of new competencies and knowledge. However, some groups could experiment with the frustration of having to abandon a path already taken that later appears to be unproductive. New responsibilities also appear on the teacher’s side, like managing the students’ proposals and finding criteria to guide the delimitation of the questions. SRPs’ questions need to be addressed in real-time, and their selection or rejection can be tainted with a certain subjectivity: what makes a question worth studying? What (and who) determines if it can be properly addressed or not? What are the assumed conditions? A new study, at the end of the activity, will shed light on these questions.



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