THE WONDERFUL LAMP OF ALADDIN? PROJECT WORK IN ENGINEERING COURSES

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In the first semester of the 2012/2013 academic year we approached teaching and learning statistics using project work. Here we will present and discuss the proposal made to the students in the Probability and Statistics course for different engineering degrees – Civil, Energy and Mechanics Engineering from a Portuguese university. In the first cycle a survey from a Master's thesis in civil engineering was the basis of a hands-on project work developed by second year students in their courses. We examined the results of the project work written reports based on the approach of Pimenta (2006) and Nascimento and Martins (2008) and related it to the Dublin Descriptors of the Bologna Process for the Higher Education in Europe.

Teaching and learning statistics is crucial in almost all degree programs because each of them has Probability and Statistics in their curricula. At the same time, the Bologna Process for the Higher Education in Europe, led to the reorganization of universities courses in Degree Bachelor (1st cycle), Master (2nd cycle) and PhD (3rd cycle). Nowadays the paradigm is officially towards student-centred learning, and students are required to accomplish several predefined Dublin descriptors (Joint Quality Initiative (JQI), 2004), to be awarded with each cycle degree. Nevertheless, this is an on-going process, and the Bologna Process Implementation Report (Eurydice Network, 2012) suggests that "[g]enuine student-centered learning is a complex matter that is difficult to integrate into everyday higher education reality. It should comprise actions that ensure that students learn how to think critically …" This teaching paradigm is closely related to our perspective on teaching and learning of statistics in all degrees. Ali et al. (2011) reinforced our belief "… that the teaching approach in basic statistics course by using real data, active involvement of students, using computer as well as using project and teamwork had been accepted as alternative approach to the traditional teaching of lecture and note-taking." Also Spence et al. (2011) is in line with our view since they suggested "… as a best practice that students receive some 'hands-on' experience with a research project." (p. 52).

From our experience with the students in the engineering courses (Nascimento & Martins, 2008), the project work approach seems to have components that motivate students to develop their work mainly aiming for the students to perceive the PPDAC (Problem, Plan, Data, Analysis, and Conclusion; Wild and Pfannkuch, 1999) cycle throughout the project work phases. Our final goal is to give students a preview to statistical reasoning and literacy. Our aim is to make them aware of the difficulties and encourage them as future professionals to discuss their future statistical work needs as they work in small groups. Given these statements, and in view of the paradigm of student-centred learning, we implemented project work with the students in the first semester of 2012/2013 academic year. In this paper, we will present and discuss the proposal we made to the students in the first semester of the 2nd year of Civil, Energy, and Mechanics Engineering at Probability and Statistics course at a northeastern Portuguese university. In the three courses of the first cycle, a survey was adapted from a Master's thesis in Civil Engineering about the energy consumptions in the residential sector. We began with a summary of the project work phases developed, and we present the results of our work based on Pimenta's (2006) items for the five components of statistical reasoning as described by Wild and Pfannkuch (1999): Recognizing the need for data; Transnumeration; Perception of variation; Reasoning with statistical models; Integrating statistic in the context. Wild and Pfannkuch (1999) also presented the PPDAC cycle for the implementation of statistical reasoning in order to develop a statistical project using the five basic components. Finally, in connection to this approach the Dublin descriptors are used to enhance students' knowledge and understanding; applying it; making judgements; communication

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of information, ideas, problems, and solutions; and their learning skills. Since we are higher education teachers, we were involved in changing the statistical courses in light of the Bologna Process in 2010 when they were planned considering the level Dublin descriptors and student-centered learning in statistics. As stated the first cycle of the Dublin Descriptors has five basic elements (JQI, 2004). So, in the scope of the content analysis of the project work products – the written reports (PW) – we felt the need to connect the components of statistical reasoning, the Dublin descriptors and the phases of the investigative cycle, PPDAC. In Figure 1 we present the parallel established between the PPDAC components of the investigative cycle, the components of the statistical reasoning and the five elements of the Dublin descriptors (Raposo et al., 2013).

Investigative cycle – PPDAC (Wild and Pfannkuch, 1999; Raposo et al. 2013)	**Components of statistical reasoning** (items of Pimenta, 2006)	**Elements of Dublin Descriptors** (JQI, 2004)
Problem (understanding and defining the problem; how do we go about answering this question) Conclusion (interpretation; conclusions; new ideas; communication)	Recognizing the need for data 1) Recognize need for data 2) Correct characterization of sample Appropriate collection of data 3) Development of a questionnaire	1) Knowledge and understanding 2) Applying knowledge and understanding
Data (collection; management; cleaning) Analysis (sort data; construct table, graphs; look for patterns; hypothesis generation) Conclusion	Transnumeration 1) Table correctly produced 2) Correct interpretation of a table 3) Graphics correctly produced 4) Graphics correctly interpreted 5) Measures of central tendency well interpreted 6) Measures of spread well interpreted 7) Summarizing key aspects with statistics	1) Knowledge and understanding 2) Applying knowledge and understanding 3) Making judgements
Plan (what to measure and how? study design? recording? collecting?) Data Analysis Conclusion	Perception of variation 1) Perception of variation 2) Perception of uncertainty 3) Numerical perception	1) Knowledge and understanding 2) Applying knowledge and understanding 3) Making judgements
Analysis Conclusion	Reasoning with statistical models 1) Reasoning with statistical models 2) Respect the method assumptions 3) Correct use of hypothesis tests 4) Correct establishment of hypotheses	1) Knowledge and understanding 2) Applying knowledge and understanding 3) Making judgements
Problem Plan Data Analysis Conclusion	Integrating statistic in the context 1) Statistics in the context (adequacy) 2) Integration of statistics in the context: oral presentation 3) Integration of statistics in the context: written report (text correctness)	1) Knowledge and understanding 2) Applying knowledge and understanding 3) Making judgements 4) Communication 5) Learning skills

Figure 1: The approach adopted for the first cycle of higher education in Europe

METHOD, RESULTS AND DISCUSSION

Figure 2 summarizes the phases of the project work developed by the teacher (only one) and students from Civil, Energy and Mechanical engineering in the Probability and Statistics course in the first semester of the second year of their degree. The project work (written reports and their oral presentation and discussion) weighted 20% of the final grade for continuous assessment (that also included 10% homework and two tests, each 35%). The student teams were made of two or three elements. From the 61 students that participated from the Probability and Statistics course, engineering degrees referred (36% of 169 that were all the students), 42 (69%) were men and 25 project work written reports (PW) were presented: 10 involving 23 Civil students out of 75, 7 involving 18 Energy students out of 45, and 8 involving 20 Mechanical students out of 49. Next, we summarize the analysis of the PW. We examined the results of the project work written reports based on the items of Pimenta (2006, Figure 1), and related them to the Dublin Descriptors (Nascimento & Martins, 2008). A content analysis was used to organize the PW categorizations.

Recognizing the need for data. All 25 groups involved in the project did recognize the need for data in their PW. In the characterization of the sample it was considered an error if students confused the words “population” and “sample” – although they meant sample (oral discussion testimonies) – we decided to consider it wrong as well as when they did not report that it was a convenience sample (56% of the 25 PW, Figure 2, Plan). All 25 groups involved in the project contributed a question to the development and improvement of the survey (PW and teacher records of PW). The main elements of the Bologna descriptors (Figure 1) were positively graded in 56% of the PW, since some important errors were detected.

General description	PPACD Cycle	Participants	Tasks
A Civil Engineering Master of Science thesis survey was chosen since the Energy Consumption in the Residential Sector is a common interest in all three degrees [1]The teacher launch the project work in class, but the main part of the work was done in the tutoring hours or by e-mail [2] The students did their project works out of class and could contact the teacher by e-mail or in the tutoring hours (in the European Credit Transfer System part the student working hours)	Problem	a. Teacher b. Students	a. Supervision and compiling work done by the groups in writing the survey and the codes tables in the word processor b. Study the main aims of the Ms. Thesis to understand the survey framework and to be able to understand if changes in the questions were needed. Each group of 2 or 3 students, defined by themselves. Write one interviewer characterization question. Type the assigned part of the survey and build the codes table for each variable of the survey question assigned in a word processor.
[1, 2] Convenience sample chosen, since it was easier to students for data collection	Plan	a. Teacher b. Students	a. Chose the sample type collection, despite its disadvantages b. Each student had to interview two house owners to get 2 surveys. Group discussion of the advantages and disadvantages of the type of sample.
[1, 2] Compiled in a worksheet file after coding each survey	Data	a. Teacher b. Students	a. Filled its one survey and built the example of worksheet with codes from the survey b. Each group made a worksheet with the codes from each survey
[1, 2] Writing the project work report and preparing the dynamic presentation of it (10 minutes out of the class time)	Analysis and Conclusions	a. Teacher b. Students	a. Compiling all the groups worksheet in one and tutoring helps of the statistical analysis b. Using the project worksheet the group had to perform the data analysis and present their conclusions (mainly descriptive statistics)

Figure 2: The project work phases for the 1st cycle of Engineering Degrees in the Probability and Statistics course

Transnumeration. Regarding transnumeration, the PW table's production was positively accomplished (76%) as well as its interpretation (64%). The major errors in PW detected in tables were the use of the codes for the variables making it unreadable, as well as some doubts about the computations of the percentages. For the transnumeration in the PW concerning graphs 52% were well done but their interpretation decreased to 44% for non-existent or confusing text. The major errors in PW were choosing the wrong type of graph (e.g., pie chart adding to 100% for multiple response items), bar chart with mode, mean and median), incorrect histograms and incorrect interpretations when a different interval width was used (e.g., ages and times of house occupation by people during the day). For measures of central tendency, 60% of the interpretations in the PW had no mistakes. We included in the spread tendency measures interpretation errors (60%) the groups that did not refer/compute any of the spread measures or reports that included in computations the codes for missing answers. Finally, summarizing the aspects with statistics 60% of the PW presented errors, mainly because of the mistakes referred to previously. Each of the Bologna descriptors (Figure 1) in transnumeration had only 40% of PW without mistakes, also mainly due to the errors described above.

Perception of variation. 52% of the PW correctly perceived the variation – presented spread measures, correct interpretations and context. The uncertainty perception was the worst item since 80% of PW were negatively graded (e.g., one of the groups wrote as a conclusion "that the Portuguese society is a society that everyday thinks more and more about the environment"). The numerical perception was the best item since 80% of the PW had positive grades (e.g., needless decimal places). Each of the Bologna descriptors in the perception of variation had 60% of PW without mistakes, but making judgments revealed poor performance, 20%; and all of these percentages due to the errors already presented.

Reasoning with statistical models. In each item of this component of statistical reasoning only three of the 25 (12%) PW used the statistical models well. This was the worst detected performance; maybe students were too busy at the end of the semester and did only a brief descriptive analysis for their PW. In our review of the main elements of the Bologna descriptors 12% of the PW were positively graded for knowledge and understanding, as well as applying knowledge and understanding. In the PW proposed, the connections between the elements of the indicator for making judgments had potential to develop the ability to make judgements, but only 12% PW fully reached it.

Integrating statistics in the context. Since students did not use the statistical models their survey analysis was incomplete. Despite this, 52% of the PW had positive grades in integrating (descriptive) statistics in the context. The oral presentations and discussions were positively implemented in 72% of the PW. The text was correct in 52% of the PW (nevertheless a second chance was given to the students for improving their texts after their presentation). The Bologna descriptors had 60% of the PW with positive grades for knowledge and understanding, as well as for applying knowledge and understanding. As mentioned before the connections between the elements of the indicator for making judgments had potential to develop the ability to make judgements, but only 52% PW reached it.

THE WONDERFUL LAMP OF ALADDIN?

As discussed in Nascimento and Martins (2008) and now reinforced, for these courses the proposed approach with the Dublin descriptors' continues to have potential to be improved with this "hands-on" PW. Despite the fact that the PW were mainly centred in descriptive statistics, students recognized the need for data as well as showed commitment since they felt motivated with the PW theme (their professional area). So our first three (statistical) wishes were fulfilled, but sadly others are still unsolved. First of all the PW should have more limited and tight timings in order to allow more feedback from the teacher to students. In the 2012/13 academic year the biggest problem found was the reasoning with statistical models, which 88% of the 25 PW groups "avoided" and these will certainly fulfil the statistical analysis, PPDAC cycle. Other rather unexpected problems were the choice of graphs and their interpretations and also measures of spread and their interpretations. This will make us more careful for next PW applications, specifically a stronger focus on analysis and conclusions from the PPDAC cycle. This work was developed in a small scale, but we learned more about the development of project work. The main insight we have from this analysis was that – perhaps – students should have access to Pimenta's items grid (2006).

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