TEACHING AND LEARNING OF STATISTICS: THE PROJECT APPROACH

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In the first semester of this school year (2007/2008) we have approached teaching and learning statistics using a different tool: the project work. Here we will present the proposals we have made to the students in the modules of different service courses. In the First Cycle (the bachelor level) a survey was conducted in the first year of the Tourism and Leisure Course in Quantitative Methods module (IPG, Portugal). At the Second Cycle (the master level), first year students were asked to collect a set of data in Zootecnical Engineering in Experimental Design module, (UTAD, Portugal). We examine the results of our work based on the approach of Pimenta (2006) and relating it with the Dublin Descriptors as implemented in the Bologna Process for the Higher Education in Europe. Finally, we will also discuss the effect of our proposal in improving teaching and learning of statistics.

INTRODUCTION

Nowadays teaching and learning statistics is a relevant theme at the universities service courses because each of them has Statistics or Statistics and Experimental Design in their curricula. The courses that do not have those subjects explicitly have other disciplines, such as, for instance, Quantitative Methods. At the same time, the Bologna Process for the Higher Education in Europe, lead to the reorganization of universities courses in three cycles. As it was quoted in the draft working document on JQI meeting (2004):

"Ministers encourage the member States to elaborate a framework of comparable and compatible qualifications for their higher education systems, which should seek to describe qualifications in terms of workload, level, learning outcomes, competences and profile. They also undertake to elaborate an overarching framework of qualifications for the European Higher Education Area.

Within such frameworks, degrees should have different defined outcomes. First and second cycle degrees should have different orientations and various profiles in order to accommodate a diversity of individual, academic and labour market needs. First cycle degrees should give access, in the sense of the Lisbon Recognition Convention, to second cycle programmes. Second cycle degrees should give access to doctoral studies."

In a simple way, the paradigm of teaching and learning in Higher Education in Europe became centered in the student, and students are required to accomplish several predefined descriptors, Dublin descriptors, to be awarded with each cycle degree (JQI, 2004). Chuchalin (2007) shortly describes those Dublin descriptors as they:

- *Set out 'general' statements for graduate competences (without specialization).*
- *Differentiate between cycles (in accordance with Bologna process).*
- *Built on the following elements: Knowledge and understanding; Application of knowledge and understanding; Making judgments; Communication skills;* [and] *Learning skills.*

As Smith (1998) wrote: *"One way to help students develop their statistical reasoning is to incorporate active-learning strategies that allow students to supplement what they have heard and read about statistics by actually doing statistics - designing studies, collecting data, analyzing their results, preparing written reports, and giving oral presentations -."*

As Binnie (2002) concluded in the ICOTS 6 paper: *"The use of projects was very helpful in assisting the learning of the students. Their active involvement in the tasks forced them to think and enhanced their learning. The use of real data of their own choice motivated them because they wanted to know what conclusions they might come to. The use of technology was implicit because all the data analysis was done on Minitab and the report written in Word. Without the projects their understanding of the process of problem solving using the statistical thinking strategy outlined would have been very theoretical."*

Biajone (2006) quotes Snee to say that *"(…) people at the University 'will study and make use of the statistical thinking when they experience its value' and learning a statistics that deals with real-world problems related to their field of study would certainly generate a more favorable attitude towards this subject and a greater desire to use it in their future career.*

The implications for statistics teaching reported in the study of Pimenta (2006) also have encouraged us. As he states: *"Current technology places the challenge of restructuring statistics teaching, in a way that we achieve the aim of transmitting both statistical reasoning and literacy. Encouraging students to do their own projects is a possible way, since in our study we found a remarkable wealth of statistical ideas in these projects."*

From our experience with the students in the services courses, the project work approach seems to have the components to motivate teachers and students to develop a cooperative work mainly aiming the students to perceive the *Statistical Method Phases* throughout the *Project Work Phases* (Biajone, 2006): Problem/theme definition; Planning; Project development; Analysis and conclusions; and Results presentation. Our final goal is to make students to be - *at least* - comfortable with *statistical reasoning* and *literacy*, not statistical experts, but encouraged professionals to discuss or consult statisticians about all the statistical work they will need to do one day in their scientific field.

In face of all these statements, and in view of the paradigm of teaching and learning arising from the Bologna Process, we implemented a project work approach with the students in the first semester of this school year 2007/2008. In this paper we will present the proposals we have made to the students in three different service courses: one at the Bachelor level (First Cycle) and two at the Master level (Second Cycle). In the First Cycle (the Bachelor level) a survey was conducted in the first year of the Tourism and Leisure Course in Quantitative Methods module (IPG, Portugal). At the Second Cycle (the Master level), first year students were asked to collect a set of data in Zootecnical Engineering in Experimental Design module, (UTAD, Portugal). We examine the results of our work based on the approach of Pimenta (2006), based on the five components of statistical reasoning described by Wild and Pfannkuch (1999), and we have tried to make a connection of this approach with the elements of the Dublin descriptors as implemented in the Bologna Process for the Higher Education in Europe. Finally, we will also discuss the effect of our proposal in improving teaching and learning of statistics.

STATISTICAL REASONING AND THE DUBLIN DESCRIPTORS

As the softwares for statistics work as a *black box* (Pimenta, 2006), the results come and we do not have to know how they have appeared. So, the statistical classes only based on the use of softwares forget the *"(…) main difficulty in education"* that, accordingly to Pimenta (2006), *"is transmitting the inherent elements of 'statistical reasoning'."* According to the summary presented by Pimenta (2006) and also by Shaughnessy (2006, p. 82), the *statistical reasoning* includes the five basic components described by Wild and Pfannkuch (1999):

"• Recognizing the need for data: The basis of statistical method is the hypothesis that many real life situations can only be understood through the appropriate analysis of previously collected data. Personal experience or anecdotal evidence is unreliable and produce misjudgments or wrong decisions.

• Transnumeration: The authors use this concept to indicate the comprehension that appears when the data representation is changed. When dealing with a real system as a modeling perspective, three types of transnumeration may occur: (1) from measurement that grasp real world qualities or characteristics; (2) when transforming raw data to tabular or graphic representation, which uncover tendencies or patterns; (3) when communicating, the meaning of data in a way which is understandable to other people.

• Perception of variation: An appropriate data collection and judgments from the same, is based on the understanding of the variation that exists and is transmitted in the data as well as of the uncertainty originated by the unexplained variation. Statistic tries to predict causes of variation, and learn from the context.

• Reasoning with statistical models: Any statistical instrument, even a simple graphic, a regression line or a statistic summary is a model, since it is used to represent reality. It is

important to differentiate the data from the model and at the same time relate the model with the data.

• *Integrating statistic in the context: This is the main component of statistical reasoning that results from the implications and conjectures originated by statistical knowledge in a given context. Statistical thinking is only meaningful when it becomes part of the context. Applying statistical methods without considering the context is a complete nonsense. For example, the conclusions we get in health sciences may not have applications in other areas."*

Since we teach in Higher Education in Europe, we felt the need to establish a parallel between the components of *statistical reasoning* and the Dublin descriptors that are used in the Bologna process. In our country the introduction of the frameworks of Higher Education in Europe, as emerged from the Bologna process, led universities to restructure the courses until 2010. In a very schematic way, according to Eva (Unknown, 2007), these are some of the implications for curriculum development in this process *"(…) New approaches to curriculum design, teaching, learning and assessment; Opportunity to revise pedagogical concepts by introducing student-centered learning, modular structures and clearly defined learning outcomes for the various degrees; More emphasis on developing skills and competencies; Greater need for individual student work, methods that lead to better communication skills, creativity and innovation; Balance between specialist knowledge and generic skills, with an emphasis on 'learning to learn'; (…) Introduction of new quality criteria emphasizing final competences; (…)"*. As a consequence, the modules of the Bologna courses should be rethinked considering the *level descriptors*, translating the level descriptors in *learning outcomes* (identifying the aim of the module), designing the assessment task thereby defining the assessment criteria and providing incentive for higher achievement through *grading criteria* in order to develop *teaching strategies* (adapted from Pereira that was referring D. Gosling and J. Moon, 2008). With this brief reference we may see the connection that should be established between the Dublin descriptors and the teaching and learning under these new European Community design for Higher Education in Europe.

As we have already stated in the introduction the Dublin Descriptors have five basic elements. Now we present Table 1 that shows them comparing the two first Cycles as they were described on the document of the JQI (2004).

Table 1: Comparing the elements of the Dublin Descriptors in the First and Second cycles

Cycle	***Knowledge and understanding:***
1 (Bachelor)	*[Is] supported by advanced text books [with] some aspects informed by knowledge at the forefront of their field of study ...*
2 (Master)	*provides a basis or opportunity for originality in developing or applying ideas often in a research context ...*
	Applying knowledge and understanding:
1 (Bachelor)	*[through] devising and sustaining arguments*
2 (Master)	*[through] problem solving abilities [applied] in new or unfamiliar environments within broader (or multidisciplinary) contexts ...*
	Making judgements:
1 (Bachelor)	*[involves] gathering and interpreting relevant data ...*
2 (Master)	*[demonstrates] the ability to integrate knowledge and handle complexity, and formulate judgements with incomplete data ...*
	Communication
1 (Bachelor)	*[of] information, ideas, problems and solutions ...*
2 (Master)	*[of] their conclusions and the underpinning knowledge and rationale (restricted scope) to specialist and non-specialist audiences (monologue) ...*
	Learning skills ...
1 (Bachelor)	*have developed those skills needed to study further with a high level of autonomy ...*
2 (Master)	*study in a manner that may be largely self-directed or autonomous...*

We choose to establish a parallel between these two groups, the components of statistical reasoning and the elements of the Dublin descriptors, since we have to work with them in the modules of Quantitative Methods and of Experimental Design (both resulting from the new Bologna process) and in the statistical reasoning domain. We do know that these five elements of the Dublin descriptors have to be achieved at the end of each cycle, but as an end these cycle

competencies may be developed since the first year of each cycle, so we dare to use them in our approach. We also had difficulty in selecting which of the five elements were more adequate for each of the five components of the statistical reasoning but we decided to go step by step. A summary of the approach we choose to use in this work is now presented in Table 2 with the parallel established by us.

Table 2: The approach we choose for the First and Second Cycles of Higher Education in Europe

Components of statistical reasoning (Pimenta, 2006)	Elements of Dublin Descriptors (JQI, 2004)
Recognizing the need for data	Knowledge and understanding Applying knowledge and understanding
Transnumeration	Knowledge and understanding Applying knowledge and understanding Making judgements
Perception of variation	Knowledge and understanding Applying knowledge and understanding Making judgements
Reasoning with statistical models	Knowledge and understanding Applying knowledge and understanding Making judgements
Integrating statistic in the context	Knowledge and understanding Applying knowledge and understanding Making judgements Communication Learning skills

METHOD, RESULTS AND DISCUSSION

We adopted a content analysis of the 12 projects presented by the 35 students at the end of the modules where we proposed the project approach, 17 students of the Quantitative Methods module in the First Cycle; and 18 students Experimental Design module in the Second Cycle. This content analysis was adapted from the items proposed by Pimenta (2006). In Table 3 we summarize the main aspects of the project approach in each module.

Table 3: Summary of the project work approach in each module analyzed

Quantitative Methods module (First Cycle at ESTTS/IPG)	Experimental Design module (Second Cycle at UTAD)
The projects were done by groups with 3, 4 or 5 students. From the total of 17 students, 9 (52.9%) were women and 3 (17.6%) were simultaneous students and workers.	Mainly the projects were done by groups with 2 or 3 students, but two students choose to do it alone. One was already working in her master thesis and the colleague that was going to work with her quit classes; and the other one only could come to classes once a month because he was already working. From the total 18 students, 11 (64.6%) were women and only 1 (5.6%) student was already working in zootecnics area.
Summary of the projects: To get a picture of the ecological behavior of the students in the school, defining the "ecological footprint", students used a proposed survey with questions added by them and doing a statistical analysis of those questions and of the “footprint” results for a specific class of the school. Making students use elementary descriptive statistics was the primary objective of this work.	Summary of the projects topics and statistical analyses used: 3 groups (2 groups of 3 students and 1 of 2 students): compared the effects on different food regimes in the growth of the animals using ANOVA. 2 groups (1 group of 3 students and 1 of 2 students): construct confidence intervals and tested hypothesis of the weights of animals growing up. 1 group (1 student): developed a survey about food handling and the general knowledge and practice in a group of workers of the food industry. 1 group (1 student): used non-parametric tests to compare weights of animals growing up and weights of independent animals (lots of different species). 1 group (three students were caught in the transition to Bologna curricula and choose to remain in pre-Bologna course but they hadn't done the experimental design module): tested hypothesis of the assumption of normality before doing the tests of proportions for ill and healthy trees in stands, and linear regression on the tree dimensions (height and diameters).
The statistical analysis was carried out with	The statistical analysis was carried out with Excel

Excel.	
The students did this project work in their working hours, out of classes, but they were encouraged to and should present their doubts during the tutorial hours.	The students did this project work in their working hours, out of classes, but they were encouraged to and should present their doubts during the tutorial hours.

We recognize that we have a *very small sample size* to apply the approach that we devised (Table 2) but this did not discourage us to present our study. Maybe the results of this first attempt will persuade us to continue with this project work approach in our Bologna modules with statistics. On the other hand, even with a small sample we can draw some generic guidelines about some key points to improve teaching and learning of statistical reasoning.

Now we present the results of the content analysis of the project work approach proposed. We use the model described on Table 2. So, we introduce this analysis with the five components of statistical reasoning and we also present a series of indicators and analyze its frequency as suggested by Pimenta (2006), but we also mention the elements of the Dublin Descriptors.

• *Recognizing the need for data* (Table 4)*:* For this component of statistical reasoning all groups from ESTTS/IPG recognized the need for data and made a correct characterization of sample. In this part of the work the tutorial classes allowed them to collect the appropriate data, even so 1 (25%) group did not do it in the right way. Despite the possibility to add some questions to the questionnaire, only 1 (25%) of the groups did it. Also all the groups From the UTAD recognized the need for data and made a correct characterization of sample. Only 1 (12.5%) of the groups choose to use non-parametric tests to compare data collected in a different context and only 1 (12.5%) of the groups developed a survey. We think that in these projects all the groups were able to recognize the limitations of their data collection of their studies.

Table 4: Frequency (and percentage) of recognizing the need for data

	UTAD			ESTTS/IPG		
	Yes	No	Not applied	Yes	No	Not applied
Recognize need for data	8 (100)	0 (0.0)	0 (0.0)	4 (100)	0 (0.0)	0 (0.0)
Correct characterization of sample	8 (100)	0 (0.0)	0 (0.0)	4 (100)	0 (0.0)	0 (0.0)
Appropriate collection of data	7 (87.5)	0 (0.0)	1 (12.5)	3 (75)	1 (25)	0 (0.0)
Development of a questionnaire	1 (12.5)	0 (0.0)	7 (87.5)	1 (25)	3 (75)	0 (0.0)

In our analysis of these projects, the main elements of the Bologna descriptors (Table 2) to emphasize were knowledge and understanding and applying knowledge and understanding (Table 2). All of the projects accomplished them in a very preliminary manner considering that they were mainly students from the first years of each of their Cycles. As we have already presented (Table 3), there were 2 exceptions in the two groups that were working the data from their master works (Second Cycle). Although they have a supervisor for their thesis, we think that they also accomplished the competencies aimed by these two descriptors by themselves.

• *Transnumeration* (Table 5): Students from ESTTS/IPG of Qualitative Methods showed some difficulties in the use of statistic techniques, which were largely covered during the module classes and in tutorials with Excel, but mostly they had great difficulties in interpreting the measures. Students of the second Cycle from UTAD were able to transform their data accordingly to each project; also they were able to interpret the measures of central tendency. With respect to the measures of spread they were able to present a correct interpretation but they were helped in the tutorials of their module. After that they were able to summarize the key aspects with statistics. One group (12.5%) that used non-parametric tests did not present graphs.

Table 5: Frequency (and percentage) of transnumeration

	UTAD			ESTTS/IPG		
	Yes	No	Not applied	Yes	No	Not applied
Table correctly produced	8 (100)	0 (0.0)	0 (0.0)	2 (50)	2 (50)	0 (0.0)
Correct interpretation of a table	8 (100)	0 (0.0)	0 (0.0)	1 (25)	3 (75)	0 (0.0)
Graphics correctly produced	7 (75.0)	1 (12.5)	1 (12.5)	2 (50)	2 (50)	0 (0.0)
Graphics correctly interpreted	7 (75.0)	1 (12.5)	1 (12.5)	2 (50)	2 (50)	0 (0.0)

Measures of central tendency well interpreted	7 (87.5)	1 (12.5)	0 (0.0)	2 (50)	2 (50)	0 (0.0)
Measures of spread well interpreted	7 (87.5)	0 (0.0)	1 (12.5)	1 (25)	3 (75)	0 (0.0)
Summarizing key aspects with statistics	7 (87.5)	1 (12.5)	0 (0.0)	2 (50)	2 (50)	0 (0.0)

In our analysis, the main elements of the Bologna descriptors (Table 2) to consider were knowledge and understanding, applying knowledge and understanding and, finally, making judgments. Also in here we have to make the same first comment as the projects accomplished them in a very preliminary manner viewing that they were mainly students from the first years of each of their Cycles with the 2 exceptions (Second Cycle) already mentioned. May be we are pushing a little with respect to making judgments; but here we were really thinking in the students choice of the graphs and of the measures and it is our opinion that in this sense students accomplish the descriptor.

• *Perception of variation* (Table 6): In our analysis we consider that the deterministic view of the reality still prevail, both to Quantitative Methods students from ESTTS/IPG and for the students of UTAD. As Pimenta (2006) presented in is study, we also think that *"(...) the students recognized the presence of variability in their data and* [almost all] *of them shoed a numeric comprehension. However few of them were clearly conscious of the uncertainty in their conclusions or in the data collected"*.

Table 6: Frequency (and percentage) of perception of variation

	UTAD			ESTTS/IPG		
	Yes	No	Not applied	Yes	No	Not applied
Perception of variation	5 (62.5)	3 (37.5)	0 (0.0)	1 (25)	3 (75)	0 (0.0)
Perception of uncertainty	4 (50.0)	4 (50.0)	0 (0.0)	0 (0.0)	0 (0.0)	4 (100)
Numerical perception	7 (87.5)	1 (12.5)	0 (0.0)	3 (75)	1 (25)	0 (0.0)

Our analysis of the main elements of the Bologna descriptors (Table 2) is has the same aspects that were presented for transnumeration. However, here the element of making judgments was not fully accomplished.

• *Reasoning with statistical models* (Table 7): As we have already presented (Table 3) the Quantitative Methods project was focused in the use of descriptive statistics, so we did not apply those indicators. On the other hand, we could perceive that half of the students of the second Cycle from UTAD deal with the concepts of models (may be they have a bigger ability to deal with abstraction) but the other half still has difficulties in reasoning with statistical models. Although the majority of the students (87.5%) make a correct use of hypothesis tests, only half of them showed that they care to correctly establish the hypothesis of those tests. The respect of the method assumptions is a weakness since students forgot to consider them in the majority of the projects (75%).

Table 7: Frequency (and percentage) of reasoning with statistical methods

	UTAD			ESTTS/IPG		
	Yes	No	Not applied	Yes	No	Not applied
Reasoning with statistical models	4 (50.0)	4 (50.0)	0 (0.0)	0 (0.0)	0 (0.0)	4 (100)
Respect the method assumptions	2 (25.0)	6 (75.0)	0 (0.0)	0 (0.0)	0 (0.0)	4 (100)
Correct use of hypothesis tests	7 (87.2)	1 (12.5)	0 (0.0)	0 (0.0)	0 (0.0)	4 (100)
Correct establishment of hypotheses	4 (50.0)	4 (50.0)	0 (0.0)	0 (0.0)	0 (0.0)	4 (100)

In our analysis of the main elements of the Bologna descriptors (Table 2) we referred for this component of reasoning with statistical methods the descriptors' elements knowledge and understanding, applying knowledge and understanding and making judgements. The first two are self explained, but here we think that in making judgements students will be closer to the end of Cycle exigencies than before. In the projects of the students of the second Cycle from UTAD the connections between the elements of the indicators for this component had potential to develop the element making judgements, but students did not fully reach it.

• *Integrating statistic in the context* (Table 8): The first semester of the first year in the ESTTS/IPG is very problematic for students and also for their teachers, in particular with respect to managing times, so this work did not include the oral presentation element. Three (75%)

groups achieved a satisfactory level of the integration of statistics in the context in terms of the adequacy and in the text correctness but, despite the fact that in this work basically descriptive statistics, 1 (25%) group did not reach a minimum level in these indicators. All the groups were able to adequately use statistics on context group of the second Cycle from UTAD and in the oral presentations all of them gave the idea that everything was all right. Nevertheless 2 (37.5%) groups had lees clear texts in their written reports living the idea that not everything was so clearly understood as we supposed.

Table 8: Frequency (and percentage) of integrating statistics in the context

	UTAD			ESTTS/IPG		
	Yes	No	Not applied	Yes	No	Not applied
Statistics in the context (adequacy)	8 (100)	0 (0.0)	0 (0.0)	3 (75)	1 (25)	0 (0.0)
Integration of statistics in the context: oral presentation	8 (100)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	4 (100)
Integration of statistics in the context: written report (text correctness)	6 (62.5)	2 (37.5)	0 (0.0)	3 (75)	1 (25)	0 (0.0)

Finally, with respect to the elements of the Dublin descriptors we think that all of them may be achieved integrating statistics in the context. However, in our opinion communication and learning skills have to be accentuated. Despite all the improvements we will have to make in order to lead students to accomplish all the five components of statistical reasoning, those two elements of the Dublin descriptors clearly led the second Cycle students at UTAD to advance towards the aims of the end of this Cycle.

TOWARDS BETTER TEACHING AND LEARNING OF STATISTICS

With regard to our study we were pleased with the results, since we think that the project approach gave an opportunity to students *"learn by doing statistics"*.

As we previously referred, in the Quantitative Methods module from ESTTS/IPG, the lack of time did not allowed a full tutorial of the groups by the teacher in the end of the Project (Analysis and conclusions; and Results presentation phases) and did not allow an oral presentation, which is clearly a weak point of this project work approach. These students revealed obvious difficulties in communicating correctly, in interpreting statistical results, in leaving their deterministic attitude and in stating their autonomy in the learning process. All this difficulties are also opportunities to us, teachers, to rethink teaching methods and curricula.

The project approach in the Experimental Design module from UTAD presented promising results. Some aspects of the statistical reasoning still have to be improved, mainly those related to the uncertainty concept: *"the need to reinforce* [students] *experience of randomness and their training in dealing with random phenomena"* (Pimenta, 2006).

For us, teachers, this first year experience in the Bologna process we lean a lot but we still have some improvements to make. We need to rethink the design of our modules in order to include more experiences with data that enable students to emphasize the weak points that overcome with this project approach. We also need to improve the management of the new Bologna curricula: module classes and module tutorials. But as we have previously affirmed: our final goal is to make students to be - *at least* - comfortable with *statistical reasoning* and *literacy*, not statistical experts, but encouraged professionals to discuss or consult statisticians about all the statistical work they will need to do one day in their scientific field.

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