RESEARCH IN STATISTICAL EDUCATION: COMPETENCE LEVEL OF SECONDARY SCHOOL PUPILS

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This communication presents an adaptation of one of the innovative learning scenarios in the European secondary education project, "EarlyStatistics", whose main goal is to improve pupils' competence in statistics. This project has just been selected for the "2009 Best Cooperative Project Award in Statistical Literacy". In this implementation, the pupils worked in a collaborative and self-governing form throughout the process. To provide an objective description of the pupils' level of statistical competence, an instrument was designed that incorporates various competence indices proposed in the literature.

INTRODUCTION

As a continuation of the line of previous research projects (Cardeñoso & Serradó, 2006; Vega, 2007), we inquire into the development of a new educational process *"And you? What do you prefer?*" ("*Y tú, ¿de quién eres?* , a title taken from an advertising catch-phrase that became part of Spain's popular culture) which focuses on statistics. The aim was to corroborate the information obtained in our first investigation, i.e., that classrooms are possible in which all the pupils consolidate and improve their starting level of competence in both cross-sectional skills and skills corresponding to our own area. To this end, we have launched a new proposal which fosters the basic principles that underpin the inclusive school (López , 2004).

The proposal that we designed and implemented in a class of 29 pupils of 15–16 years old adapts one of the learning scenarios proposed in the EarlyStatistics program (http://www.earlystatistics.net; Socrates-Comenius Action Project 226573-CP-1-2005-1-CY-COMENIUS-C21), focusing on the recreational activities and other typical aspects of today's youth. The present communication presents this proposal of educational innovation on which our research was based, together with a description of the indicators that allowed us to check whether or not the research objective had been attained.

RESEARCH OBJECTIVE

The research objective is: "To analyze and characterize the possible evolution of statistical competence of pupils in an inclusive compulsory secondary education classroom through the project *And you? What do you prefer?* integrated into an overall educational setting of learning."

The data from the instruments used in the study (forming part of the portfolio) are currently being selected, organized, and categorized in terms of the referents of analysis. For this purpose, we have developed a set of indicators of the statistical competences worked on in the activities with which to extract information on the impact of the process on our pupils' statistical competence.

THE SCHEME OF THE EDUCATIONAL PROCESS

The theoretical framework of the educational proposal is the theory of situated cognition which is oriented towards the proposal of meaningful practical activities related to the pupils' real environment. The purpose is to foster the acquisition of meaningful learning in a context of cooperative work on projects that include activities requiring processes of information search and retrieval and decision making on the part of the pupils. The activities carried out during the process formed the individual and group portfolio. Another significant element in the proposal is the degree of cultural relevance of the topic, since it involves the pupils in a real statistical study of clear interest to them. Indeed, we believe that the pupils' capacity to reason statistically can be considerably improved by working on real scenarios.

The process begins and ends with two individual activities in which pupils are asked to resolve a problem task. This provided us at the end of the process with data about whether or not the students' level of statistical competence had indeed evolved. Intermediate between these two

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data collection points, we placed the learning activities which were worked on in groups, and were structured into four distinct methodological moments or phases.

- In the first, they worked on four activities designed by the teacher in which they were set a series of tasks/problems analyzing information taken from an official report (INJUVE'08). At the end of each of these activities, certain theoretical notions were presented concerning the statistics that had been used. Each group followed its own working rhythm in that they only went on to the next activity when they had completed the previous one, with each pupil writing up a personal report about the task.
- In the second phase, each group prepared a mural as synthesis of all the noteworthy information gathered the four activities they had carried out, the aim being to present it to the rest of the class. The pupils prepared a "*rubric*"–an explicit contract consisting of the categories and value ranges to be used to evaluate the process.
- The third phase consisted of uniting all the groups into one large group that we call an "*assembly*". This allowed dialogue on the procedures used in resolving the activities of the first phase, on the different theoretical notions that were used, and on deciding what steps need to be followed in a statistical inquiry.
- In the final phase, each working group decided what statistical variables they wanted to study. They then specified the design and development of their own particular project involving an independent, self-guided statistical study in which they were to follow steps similar to those previously agreed on in the assembly. This project had to have a final output that reported the conclusions the group had reached, and had to be accompanied by a dossier describing the steps taken to reach those conclusions.

COMPETENCE LEVELS

To determine the degree of attainment of the goals of the study, we made observations of two mathematical types of skill – argument and reasoning.

To characterize the statistical competence level of the group objectively, we designed an instrument combining the indicators that had been proposed by other workers (Niss, 1999; OECD, 2004; Henning, 2005) which allows the competence skills of the pupils under study to be detected. Thus, taking as reference the published descriptors of what would be the six levels of competence for the scale of uncertainty (OECD, 2004), we regrouped and adapted them into three levels of competence in statistics, based on the pyramid model as shown in Figure 1 (De Lange, 1999):

- Level 1: Basic–Reproduction and routine procedures.
- Level 2: Intermediate–Connection and interpretation of standard problems.
- Level 3: Advanced–Reasoning, argument, and generalization of problems.

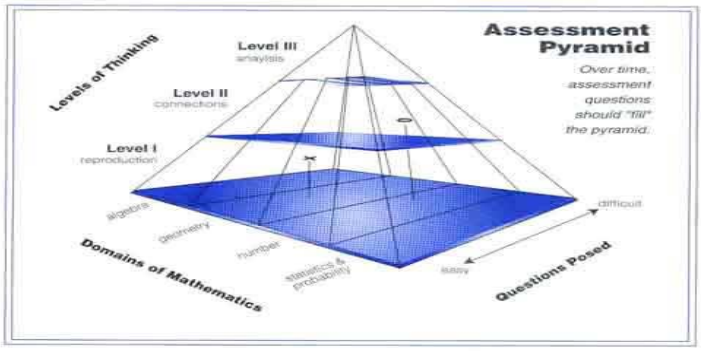


Figure 1. Pyramid model of competence

The descriptors defining each of these levels are given in Table 1.

Taking as basis the characteristic skills of the different competence levels, we specified a set of more than 40 indicators for each level allowing us to characterize the pupils' actions and expressions and the level of competence that would correspond to the observed response.

With these indicators, which were presented at the XIII SEIEM Symposium (Vega,

Cardenas & Azcarate, 2009), we can place the pupils at a certain level of competence on the basis of the observation and evaluation of their responses and actions.

Table 1. Descriptors for each level of competence

LEVEL 1	LEVEL 2	LEVEL 3
A. Understand and use basic statistical ideas in familiar experimental contexts. B. Look for statistical information presented in a familiar graphical format. C. Understand and use basic statistical concepts and conventions.	A. Interpret statistical information and data; relate it to different sources of information. B. Perform basic reasoning with elemental statistical concepts and symbols; communicate that reasoning. C. Use basic statistical concepts combined with numerical reasoning in less familiar contexts to solve simple problems. D. Perform calculations that are sequential or involve different steps. E. Use and communicate arguments based on the interpretation of data.	A. Apply statistical knowledge in problem situations that have a certain structure and where the mathematical representation is in part apparent. B. Use reasoning and understanding to interpret and analyze given information to develop appropriate models and represent sequential calculations; communicate the explanations and arguments. C. Use a high level of thinking and reasoning skills in statistical contexts to create mathematical representations of real world situations. D. Use understanding and reflection to solve problems; formulate and communicate the arguments and explanations.

AN EXAMPLE OF AN ACTIVITY AND ITS EVALUATION

By means of these different instruments, we obtained significant information concerning the process of teaching and learning, without causing any disturbance to the rhythm of the course. To this end, the activities that were instruments of both information and data collection were designed with the same structure as the learning activities. This helps us detect the pupils' different actions in a context of similar tasks, and hence form a picture of their level of skill in the various competences.

We associated benchmarks with the proposed tasks in the sense of fixing on certain expected actions so as to make the association of the pupils' observed actions with the previously defined competence level indicators more objective and clear. However, it is a complex process to determine indicators for each statistical competence level descriptor, and set benchmark or reference actions for each task.

The association between benchmarks and indicators was done as transparently as possible so that it would thus be also as clear and objective as possible, and is being reformulated by contrasting it with the data. By way of illustration of how we relate benchmarks and indicators, we present the seventh task in the initial individual activity for collecting the baseline data of the study.

Seventh task

In previous tasks, they had been asked about the sample and the population referred to in a statistical study described in a newspaper article. The aim of that study was to describe the drug use habits of Spanish youth, and to determine their opinion about it.

In this specific task, the pupils were asked about the representativeness of the sample, and to reason their decision.

The benchmarks we considered for this task were:

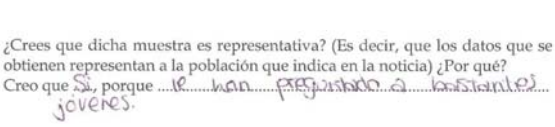
- Intuitive concept of representativeness: recognize and characterize the representativeness of a sample, irrespective of the recognition of the sample itself.
- Reason coherently for their criterion of recognition or belief using: the given data itself; subjective examples; related elements and ideas; logical induction; reasoned deductions.
- Give a summary and/or reasoned critique that is: personalist; determinist; contingent; causalist; indeterminist.

Each of these benchmarks was associated with one or more competence level indicators to make it possible to extract as much information as possible about the pupil's level of competence in this task.

For example, we associated two Level 1 indicators with the first of the mentioned benchmarks ("Intuitive concept of representativeness: recognize and characterize the representativeness of a sample, irrespective of the recognition of the sample itself"):

- N1. A. i. (first indicator of the first descriptor of the first level). Recognize basic statistical ideas in familiar simple contexts.
- N1. B. i. (first indicator of the second descriptor of the first level). Identify basic statistical expressions in a familiar text.

Figure 2 shows the response of a pupil who, although she indicates that the sample is representative when it really is not, does however demonstrate that she possesses the intuitive concept of representativeness, because she recognizes and characterizes it even though subsequently she is unable to recognize whether or not the sample is indeed representative.



Do you think that this sample is representative (in other words, that the data obtained represent the population indicated in the news item)? Why?
"I think ***so***, because ***they asked many young people.***"

Figure 2. Response to Task 7

In this case, we can conclude that the pupil has the knowledge of the first level of competence, at least with regard to this first benchmark of the task. We now have to proceed with the detailed analysis of each of the benchmarks of this and the other tasks, to determine the pupil's level of competence in the initial activeness as a whole.

We note that there are characteristics which are unobservable directly, for instance, *understanding*–how can one determine whether a pupil has understood a statistical idea? For this reason, this first approach, as an emergent system of data analysis which was designed within the theoretical framework put forward by Niss (1999) and the OECD (2004), is now being polished, supplemented, and amended in light of the data that were obtained in the present study.

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