LET US DO IT IN A DIFFERENT WAY? AN ALTERNATIVE ASSESSMENT PROPOSAL

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We believe that without the participation from students, effective learning will not be achieved. So, last year (2005/2006) we have tried to improve students learning in statistics using different assessment tools. Here we will present the proposal we have made to the students and we will discuss the results of one of the tasks we have proposed to them. Finally, we will also discuss the effect of our proposal to improve student's learning in statistics.

INTRODUCTION

Since we have began our teaching introductory statistical courses we have felt the need to improve the way of doing everything - teaching and learning, and assessing -, but only recently we have found guidance to begin to make those changes [e.g., Batanero, 2001]. *Instead of traditional lectures where teachers "tell" students information that they are to "remember", teachers are encouraged to introduce active-learning activities where students are able to construct knowledge.* (Garfield, 1993). We are trying but we know that we are not yet there. We also agree that *"(…) the learning of statistics must move from passive to active. We face many challenges when teaching an algebra-based introductory statistics course. (…) One of our principal goals as teachers is to engage students in the subject and to teach them that statistics is full of ideas and methods that will make them more informed users of the information they encounter every day"* (Aliaga, 2000).

Until last year (2005/2006) the students of our introductory statistical courses were assessed using traditional grading of tests and exams. But we were not at all pleased with the performance of students and then with our own performances: *"(…) final exams were made based on procedures, definitions, and skills, rather than real conceptual understanding."* (Garfield & Chance, 2000). Along the years something was also missing in assessment of student performance and we felt the need to improve students' participation by collecting information from sources other than individual student exam. As we don't have computer laboratories our courses don't have lab classes and so each student couldn't work at a computer in class. Students either use their own computer, or the university places outside classes (e.g., library). This was the reason that led us to devise an alternative assessment proposal: weekly *technological* homework assignments. By *technological* homework we mean that in almost all assignments we have proposed a task with internet applets or other software (e.g., Excel spreadsheets). Those homework assignments should be done in small groups and each group had to present a small written report that was graded and discussed with the students. Those works were only considered for final grades (10%) if students attend half of the lectures of the course.

Using those technological tools in almost homework assignments we were making a small move to broad student's experiences. *It has been argued that supplementing the traditional material with tools based on a visual approach and a more active form of learning could improve the effectiveness of the teaching.* (Darius et *al.*, 2002). On the other hand Godino et *al.* (2003) had already mentioned the use of applet for teaching statistics in schools. *The applet facilitates the construction of the student's personal exploration scenarios. However, progress in this exploration as supported by interactive programs, necessarily requires the teacher's contribution. This is a new challenge for the teacher who needs simultaneously to help students who are at different points of the learning process.* Phillips (2003) also said that: *Many students gain a better understanding when visual images are used to explain statistical concepts.* But despite our motivation we must keep our feet on the ground. As it was remembered by Martins (2006), *"(…) these software programs don't solve teaching problems by themselves (…)"*.

A last remark about the alternative assessment proposal – the weekly *technological* homework assignments –, this proposal was presented to the students in the beginning of the semester: we have invited them to participate in the course in a different and more ambitious way, with the slogan: let us do it in a *slightly* different way.

Finally, we also "(…) *concur with Garfield's suggestion to attempt to incorporate only one new assessment technique at a time. These techniques can be quite time consuming and demanding on the instructor, and need to be well organized and thought out ahead of time"* (Chance, 2000).

THE ALTERNATIVE ASSESSMENT PROPOSAL

As we have already described in the weekly *technological* homework assignments we have almost always proposed a task with internet applets or other software (e.g., Excel spreadsheets). In Table 1 we summarize those tasks.

Table 1
Tasks topics for the technological homework assignment

Task	**Topic**	**Methodology**	Resources
1	Data sets and their graphical representations	Small paper: written report	Magazines
2	Comparing means and medians	Written report and investigation	On line applet (http://standards.nctm.org/document/ eexamples/chap6/6.6/index.htm)
3	Least-squares regression line	Written report and investigation	On line applet (http://standards.nctm.org/document/ eexamples/chap7/7.4/index.htm)
4	Probabilities	Written report, building spreadsheet model and simulation	Spreadsheet
5	Conditional probabilities	Written report and simulation	On line text and applets (e.g., Pinkney, 2005;http://www-stat.stanford.edu/~susan/ surprise/ProbabilityTree.html7 available on 11.10.2005)
6	Dependent and independent events	Written report, research on day-to-day situations	On line text and applets found by the students or books and scientific papers
7	General probability laws	Written report and simulation	On line text and applets (e.g., http://noppa5.pc helsinki.fi/koe/dice/dicesim1.html;http://www. shodor.org/interactivate/activities/spinner/inde x.html) or spreadsheet
8	Discrete probability laws	Written report , research on day-to-day situations and simulation	On line text and applets (e.g. http://highered.mcgraw-hill.com/sites/dl/free/0072868244/124727/Bin omialApp.html; http://www.stat.sc.edu/~west/applets/binomial demo1. html) or spreadsheet
9	Discrete probability laws	Written report and simulation	On line text and applets (e.g., http://www.math.csusb. edu/faculty/stanton/m262/hypergeometric_dist ribution/hypergeometric_distribution.html; http://stat-www.berkeley. edu/~stark/Java/Html/ProbCalc.htm; http://www.math.cs usb.edu/faculty/stan ton/probstat/loto.html) or spreadsheet
10	Continuous probability laws	Written report on day-to-day situations and tables	On line applets (e.g. http://kitchen.stat.vt.edu/ ~sundar /java/applets/Normal.html; http://www.stat.sc.edu/~west/applets/normald emo1.htmll) and spreadsheet for building tables for the usual probability laws

Task	**Topic**	**Methodology**	Resources
11	Continuous probability laws and convergences	Written report on day-to-day situations and problems with tables	On line applets or spreadsheet for computations
12	Comparing central tendency measures and spread measures	Written report and simulation	On line applets (e.g., http://standards.nctm.org/document/ eexamples/chap6/6.6/index.htm; http://www.stat.yale.edu/Courses/1997-98/101/rvmnvar.htm)
13	Confidence intervals	Written report and simulation	http://www.amstat.org/publications/jse/v6n3/applets/confidenceinterval.html; http://www.stat.berkeley.edu/users/ stark/Java/Html/Ci.htm

Now we present *Task 2* in a detailed form because we will discuss the results of it. This task was translated and adapted from *Comparing Properties of the Mean and the Median through the use of Technology* (NCTM, 2007): *The seven data points in the line plot below in the applet represent seven points in a sample:* A=63, B=149; C=250, D=287, E=374, F=330, G=400. *Your task is to explore how changing one (or more) of the data points affects the mean and the median of the data set. The following questions may be useful in focusing your experimentation:* **a)** Choose a day-to-day situation that might be described by the points of this sample. **b)** Compute by any means outside the applet the values for the mean and for the median of this sample. Are they the same of the applet? ***c)*** *Can you find ways to move the data points that keep the median the same but change the mean?* ***d)*** *Can you find ways to move the data points that keep the mean the same but change the median?* ***e)*** *How do the mean and median change when you keep the points in the same order but just change their positions on the number line?* **f)** What happens to the mean and to the median if you pull all of the data values nearby zero or to the other extreme nearby 400? ***g)*** *By moving data points, can you construct data sets in which the mean seems to be a typical value but the median is not? And what if vice versa? For what types of data sets, if any, is the mean not very representative? When is the median not very representative?*

Those tasks were proposed to (about) 200 students from introductory statistical engineering courses of Environment (EE), Forestry (FE) and Zootecnics (ZE). Among them about half did the homework assignments forming 33 small groups (with 2, 3 or 4 students), 48% were from EE, 7% from FE and 30% from ZE.

To present our analysis of this task we decided to adopt the median properties described by Cobo and Batanero (2000) and the mean properties adapted by us to use in this analysis. In Table 2 we summarize the guidelines for the median and mean properties we have used here.

Table 2
Mean and median properties analyzed (translated and adapted from Cobo & Batanero, 2000).

Properties	**Median**	**Mean**
Numerical When we consider the median as number.	3. Median is invariant if data below it changes or if data above it changes.	3. Mean vary with all the data change; in a rough way if mean don't vary data change are symmetrical.
Algebraic When we consider the median as a computation		
Statistical When consider median a central tendency measure (CTM)	2. Median may represent a sample and gives information about it. 3. It is a resistant statistic. 4. In a symmetrical distribution median, mean and mode coincide (in unimodal distributions). 5. In a right asymmetrical distribution mode-median-mean is the CTM's order and mean-median-mode in a left asymmetrical distribution (in unimodal distributions). 6. In an asymmetrical distribution median is preferred to mean as a CTM.	2. Median may represent a sample and gives information about it. 3. It is a less resistant statistic. 4. In a symmetrical distribution median, mean and mode coincide (in unimodal distributions). 5. In a right asymmetrical distribution mode-median-mean is the CTM's order and mean-median-mode in a left asymmetrical distribution (in unimodal distributions). 6. In an asymmetrical distribution median is preferred to mean as a CTM.

Now we present our analysis to the questions of the written reports for *Task 2* also based on the topics we have presented in Table 2. This is our first analysis, merely descriptive.

Question a) – We wanted to see how far students could think in data connected to day-to-day examples. So we analyzed if the examples they wrote were suited to realistic examples and if they were adjusted to the data sample presented. At last we merely divided the examples as quantitative discrete or continuous variables. We considered 85% suited examples and we had only 22 of the 33 examples that we considered adjusted examples for the data provided. From all of the examples 63% described continuous variables.

Question b) – With this question we wanted students to test their way to compute mean and median and to compare their results with those from the applet. In the last point there were no disagreements, but students had some difficulties in explaining the way of computing their medians, only 79% of the groups wrote a good report about it. The performance grew up with reports about computations of the mean, 91%.

Question c) – Here students had to investigate and also report and we focused our analysis on their use of numerical property 3 (Table 2) for the median and for the mean. Almost all the groups wrote good reports about numerical property 3 for the median, 79%, and for the mean, 82%. We analyzed if students had devised strategies and had correctly reported them: only 64% had fair answers. One group (3%) did not answer the question.

Question d) – Here students had to investigate and also report and our main goal was to analyze, once again, their use of numerical property 3 for the median and the mean, where the role of the median and mean change with respect to the previous question. Almost all the groups wrote good reports about numerical property 3 for the median, again 79%, and even better for the mean, 85%. We also analyzed if students had devised strategies and had correctly reported them concluding that just only 58% had suited answers. Here again, one group (3%) did not answer the question.

Question e) – Here students had to investigate and report and we focus our analysis on their computations for the median and for the mean. We analyzed if students have devised strategies and have correctly reported them. Only 42% had fair reports about the medians and 30% about the mean. Here three groups (9%) did not answer the question.

Question f) – Here students had to investigate and report and we focused our analysis on their knowledge about statistical properties 2 and 3 for the median and for the mean. Here 79%

had good reports about the median and 82% about the mean. Here again, one group (3%) did not answer the question.

Question g) – Here students had to investigate and report and we focused our analysis on their knowledge about statistical properties 2 and 3 for the median (g.1) and for the mean (g.2). We also focus our analysis on their knowledge about statistical properties 4, 5 and 6 for the median (g.3, mainly symmetry issues) and for the mean (g.4, mainly symmetry issues but we also accepted dispersion references). At this point the written reports reveal poor performances for the median g.1, 24% and for the mean g.2, 27%, they were also poor for the median g.3, 18% and a little better for the mean g.4, 48%. Here six groups (18%) did not answer the question.

DISCUSSION AND CONCLUDING REMARKS

After our presentation we want to comment that it was very interesting to discuss our views with the students and how profitable for all of us it was. The set of answers we had in our first question (**a**) was very broad and the students understand all the comments we made about in the care they need to put in future connections between examples and data samples presented. Surprisingly 63% of the examples were from continuous variables. We have also discussed it bearing in mind some possible ways of defining and dealing with data. About the second question (**b**) the talk with students reinforce the need they have to put in clear ideas so they may write simple and also clear reports, and everyone agreed that this point must be improved. Median computation difficulties (Cobo & Batanero, 2000; Batanero, 2001) were once again reviewed. The main topics considered and argued with the students in questions **c**, **d**, **e**, **f** and **g** were the lack of examples in their written reports, sometimes the *too* much similar examples presented and above all the lack of explicit and clear report of the strategies they have used in their investigations. Students argued that it was a new kind of demand so they were not used to it. We also have shown our disappointment for the lower performances in question **g**, including the six groups that did not answer it. From the discussion arose the question of the meaning of *typical value* for the mean and for the median and the meaning of *representative* mean and median. Some of the students did not connect those meanings with the symmetry issue we have planned to explore with those questions. So we have had the opportunity to discuss those topics again.

For us it was clear from the analysis of all the questions that the last questions were considered the most difficult ones and that the students were not able to write good reports about either their investigations or the strategies they have used. Sometimes it was not very clear if the students had used the applet to draw their conclusions, so its use in a lab session should be probably much more advisable for this kind of work.

One of our final remarks is that the task seems simple to us for those students, nonetheless it revealed some misconceptions when *Comparing Properties of the Mean and the Median through the use of Technology*, namely when we have proposed to the students two different ways of doing their work: use an applet to investigate and write down your investigations. The written reports were a good starting point to the exchange of ideas with the students: we began to know each other better and bridges were built and were developed along the semester with the other *technological* homework assignments.

Finally, we repeat *"(…) Garfield's suggestion to attempt to incorporate only one new assessment technique at a time"* (Chance, 2000). *These techniques* are *really quite time consuming and demanding on the instructor* and on the student if he really cares, *and need to be well organized* and re-organized for future work. We have done it in a *slightly* different way and we did not regret it.

REFERENCES

Aliaga, M.B. (2000). Discussion. In C. Batanero (Ed.) *Training Researchers in the Use of Statistic*. Granada: IASE. Retrieved March 31, 2007 from: http://www.stat.auckland.ac.nz/~iase/publications/9/069.pdf.

Batanero, C. (2001). *Didáctica de la Estadística*. Departamento de Didáctica de la Matemática. Universidad de Granada.

Chance, B. (2000). Experiences with Authentic Assessment Techniques in an Introductory statistics Course. In T. L. Moore (Ed.) *Resources for Undergraduate Instructors - Teaching Statistics* (pp. 209-218). USA: MAA & ASA.

Cobo, B. & Batanero, C. (2000). La mediana en la educación secundaria obligatoria: ¿un concepto sencillo? *UNO, 23*, 85-96. Retrieved March 31, 2007 from: http://www.ugr.es/~batanero/ARTICULOS/MEDIANA.pdf.

Darius, P., Michiels, S. & Raeymaekers, B. (2002). Applets for Experimenting with Statistical Concepts. *In Technology in Statistics Education ICOTS 6*, South Africa. Retrieved March 31, 2007 from: www.stat.auckland.ac.nz /~iase/publications/1/7a2_dari.pdf.

Garfield, J. (1993). Teaching Statistics Using Small-Group Cooperative Learning, *Journal of Statistics Education*, 1. Retrieved March 31, 2007 from: http://www.amstat.org/publications/jse/v1n1/garfield.html.

Garfield, J. & Chance, B. (2000). Assessment. In T.L. Moore (Ed.) *Resources for Undergraduate Instructors – Teaching Statistics* (pp. 199-200). USA*: MAA & ASA.*

Godino, J. D., Ruiz, F., Roa, R,. Pareja, J. L. & Recio, A. M. (2003). Analysis of Two Internet Interactive Applets for Teaching Statistics in Schools. *In Statistics & the Internet, IASE,* Germany. Retrieved March 31, 2007 from: http://www.stat.auckland.ac.nz/~iase/publications/6/Godino.pdf.

Martins, J. A. dos S. V. (2006). Statistics Visualization with Dynamic Geometry. In A. Rossman, B. Chance (Eds.) *ICOTS 7*, Brazil: IASE and ISI. Retrieved March 31, 2007 from: http://www.stat.auckland.ac.nz/~iase/ publications/17/7E4_ MART.pdf.

NCTM (2007). *E-Example 6.6. – Comparing Properties of the Mean and the Median through the use of Technology*. Retrieved March 31, 2007 from: http://standards.nctm.org/document/eexamples/chap6/6.6/index.htm.

Pinkney, M. (2005) Probability. In MathsRevision.net. Retrieved March 31, 2007 from: On line http://www.mathsrevision.net/gcse/pages. php?page=32.

Phillips, B. (2003). Overview of Online Teaching and Internet Resources for Statistics Education. *Statistics & the Internet, IASE,* Germany. Retrieved March 31, 2007 from: http://www.stat.auckland.ac.nz/~iase/publications/6/Phillips.pdf