HOW TECHNOLOGY CAN HELP OR COMPLICATE THE TEACHING OF STATISTICS DEPENDING ON THE CLASS SIZE

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Technology is part of the new reality in the educational system. Students use it, and teachers need to find new ways to engage students. Web 2.0 is the turning point in which the World Wide Web can be used to fully enhance the creativity of its users with its many instruments available, such as blogs, social-networking sites, video sharing sites and wiki pages, just to mention a few. The richness and diversity of subjects that Statistics encompasses, together with the WWW, creates an environment of excellence in which students play an active role in the entire learning process. It is our goal to show how the use of these new technologies can promote, in both small and large classes, the knowledge and understanding of statistics in an environment that, although tailored for each student, encourages the student to interact with his/her classmates, creating a vivid environment that enhances their learning potential.

INTRODUCTION

It is difficult to imagine a statistics class nowadays without the use of some kind of Information and Communication Technologies (ICTs). ICTs have had a massive impact on the teaching and learning process and are an essential tool in all areas of knowledge. Just to mention a few examples, in a statistics class the use of ICTs are present for both teacher and students when:

- Different software is used for an exploratory data analysis or data modeling
- Multimedia projectors are used to explore theoretical concepts through simulation studies
- Students use their own laptop to accomplish the tasks proposed in a class
- Learning Management Systems (LMS) are used to give timely teacher feedback to the students.

We can observe in these simple examples how ICTs can be used through the entire learning cycle expressed in Figure 1. The *Learning Path*, where the student is learning through data analysis in a hands-on environment working with software, or in a more rhetorical way where students are exposed to different theoretical concepts through simulations, such as the central limit theorem or the interpretation of confidence intervals. In *Self-reflection*, the student will then spend some time collecting evidence about his/her advancement and understanding the concepts addressed in class and, in a suitable format, will send these reflections and findings to the teacher and/or classmates. Finally, timely teacher and/or student *Feedback and Assessment* can be done through any Learning Management System.

The Web 2.0 with its web-based communities, hosted services, web applications, social-networking sites, video-sharing sites, wikis and blogs, among others, will help teachers to capture students' attention and win students' attitudes over towards statistics. The website is no longer viewed as a static tool where people are limited to the information placed by others. Users can now interact with other users or be an active part in changing the content of a website.

ICTs are powerful tools that can and should be used by both teachers and students, engaging them in meaningful discussions, developing statistical knowledge and enhancing the learning and teaching process. As Peralta (2009) mentioned "*We have to persuade our teachers that knowledge is open and undeniable to all. Knowledge that is shared grows and improves*". In this proposal, we will discuss different technology resources, their limitations depending on the class size, and possible solutions to overcome some of these limitations.

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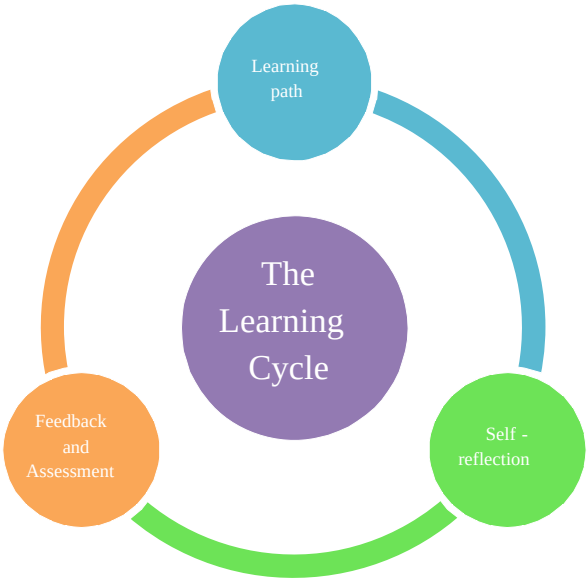

Figure 1. The Learning Cycle

TECHNOLOGY CHALLENGES

When introducing technology in teaching statistics, inherent challenges need to be addressed. Content, methodology and format of the courses will naturally change due to the particularities of the new tools available. Technology offers new methods of visualizing and exploring data, creating greater potential to propose new methods of data analysis. For example, with the help of calculators and computers, *p-values* are now much easier to calculate when compared to how it was done with the use of tables, or even the simple calculation of a standard deviation. Time that was spent in calculations in the past can now be used to explore the interpretation of the concepts, ideas, and to study more complex models. Bayesian methodologies are a perfect example that profit from great advances in computers and the development of free software, overcoming some of the difficulties in the implementations of MCMC methods when fitting highly complex models.

Unfortunately, technology is not on its own a learning object. Garfield and Ben-Zvi (2008) wrote that "*More appropriate uses of technology are accessing, analyzing, and interpreting large real data sets, automating calculations and processes, generating and modifying appropriate statistical graphics and models, performing simulations to illustrate abstract concepts and exploring*". Thus, teachers need to select the appropriate tools to be used in their classes, validate the different techniques used in the data analysis, facilitating the discussion of the results and encourage students to present their final conclusions. New roles for teachers and students must be assumed.

But there are limitations. Often teachers complain about too much work when using ICTs. Like a double-edged sword, the use of technology may result in an overwhelming situation where many activities must be assessed in the case of large classes. Thus, class size is a major factor to be taken into consideration when planning to use ICTs.

New, challenging web 2.0 tools give us the opportunity to address this issue when used with the appropriate methodology. We need to engender new roles in our students so that they become more active and collaborative. Web 2.0 tools enhance these roles, facilitating the work of the teacher. These are tools for supporting relationships, allowing for learning as a collaborative endeavor to occur.

Taking into account the learning cycle (Figure 1) we ask ourselves how a student can dynamically interact in the learning, tutoring and assessment process and what the consequences will be of such a role taken by a student. First, methodology can be used into the social constructivism paradigm as a way to enable students to be active in their own learning, where

Blogs, Wikis or Social Bookmarks are just some examples to be considered in this approach. Secondly, methodology can also consider students assuming roles that traditionally belong to teachers, such as tutoring and assessment, which we shall refer to as peer tutoring and peer assessment, respectively.

SOCIAL CONSTRUCTIVISM

Blogs and Wikis are common tools in our lives, suitable for knowledge construction. They may be used to produce a variety of contents to be shared by all. Therefore, we can make use of these tools to enable our students to construct their own statistical knowledge.

As an example, consider the post embedded in the Administrative Statistics class in Figure 2. The post offers a videocast from YouTube performed by students about some statistical issue. This video was part of an activity where a group of students explain a statistical concept within a virtual environment to the rest of the class.

Figure 2. Video embedded into the Administrative Statistic Blog

Google Analytics, Google Forms, Gapminder, Google Search and Google Spreadsheet are examples of other Web 2.0 tools available for statistical purposes. There are many other tools that, although not statistical in nature, allow students to construct significant learning on statistical issues. The most important is to use technology suited for both students and teachers in the development of students' statistical reasoning, so that students can play an active role in constructing statistical meaning to their learning. Some examples are presented in the following sections.

PEER ASSESSMENT

Assessment has been traditionally a role performed by teachers, but can now be considered as an active part in the entire learning process when performed by students. For this purpose, a predefined system of rubrics needs to be created to guide the peer assessment process. As an example, we present the comments that students made to the videocast posted on the blog above in Figure 3.

The process comprised the following two steps:

Step 1: An activity is proposed to be done individually or in groups using a blog or a wiki;

Step 2: Every group or every student uses a rubric to assess another group or student.

Technology allows us to gather evidence within the evaluation process with little effort, so the student does not need to spend too much time formatting the material. Step 2 can be done anonymously and, although we have used here a videocast, other materials such as images, podcasts or audio records can be considered as evidence of the students' learning progress.

This process overcomes some of the limitations of e-Portfolios when applied to large classes. In de Sousa and Novegil Souto (2008) a series of examples are presented, illustrating the

construction and maintenance of an e-Portfolio. It is easy to imagine the overwhelming amount of work that falls on a teacher with larger classes. Peer assessment, with the help of ICTs, will encourage teachers to create a real and vivid environment that enhances students' learning potential.

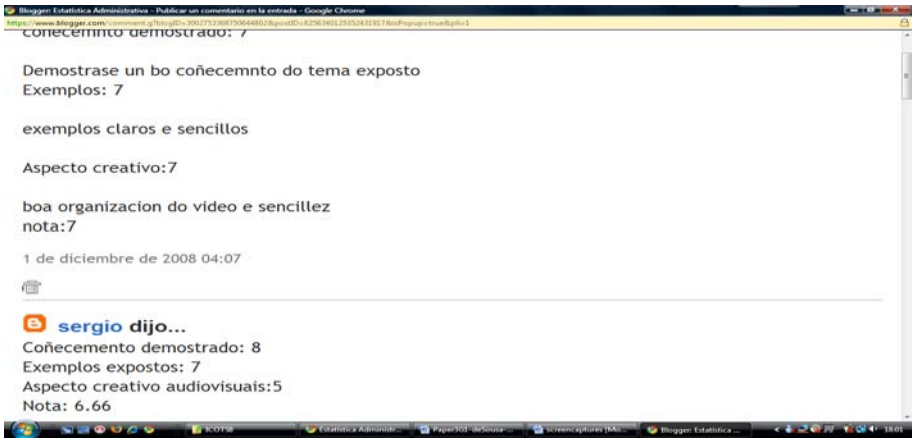

Figure 3. Peer Assessment comments using a specific rubric

PEER TUTORING

Life Long Learning or Learning to Learn are two important topics in the learning process. Both are related to self-regulate learning where motivation to learn, planning, monitoring, and evaluating personal progress are part of the process. One of the main characteristics of Web 2.0 tools relies on social relationships. Introducing supervising and learning within students as part of a social class network can facilitate self-regulated learning. As a way to lighten the work load from a teacher and make students accountable in the learning process, we propose a system of peer tutoring using a Forum environment. The activity is as follows:

Step 1: Any type of question may be posted by a student in a Forum (Figure 4) or a Blog;

Step 2: Other students explain concepts and procedures regarding this specific question.

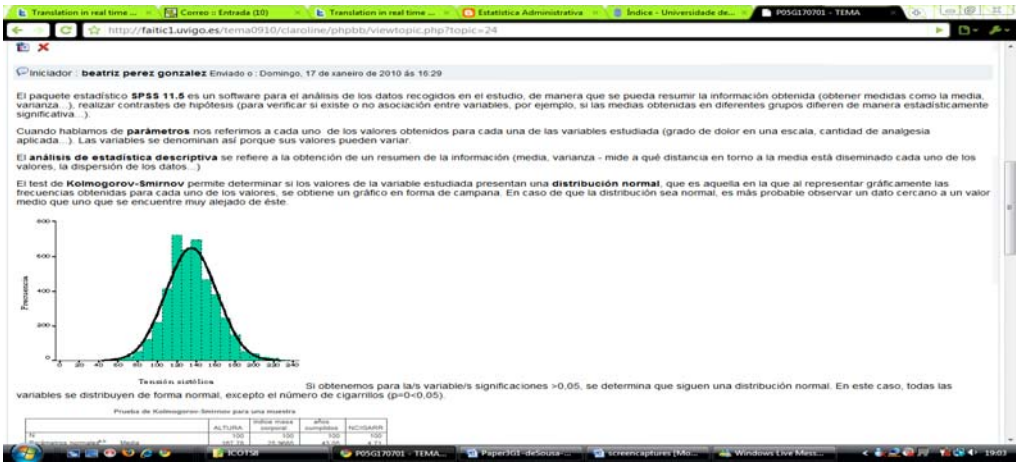

Figure 4. Explaining Kolmogorov-Smirnov Test at the Forum "Houston, we have a problem"

The role of a teacher is simply that of a supervisor, guaranteeing the validity of the answers given by the students and assessing their difficulties within a friendly environment. The teacher can then lead the student in reflecting and understanding the core statistical concepts addressed in class.

IN-CLASS ANALYSIS AND RESULTS

What tools must we select?

An anonymous survey was conducted with all students in class (n = 25) in order to get more information about the advantages and disadvantages of the main tools used in class. The results were:

- iGoogle tools were considered easy-to-use by students (85.71%) and the flexibility that it allows in creating a personalized environment (80%) was noted
- Google Docs has statistical tools suited to an introductory course in statistics, facilitating collaborative work. Tools like *Google Forms* and *Google Spreadsheet* allow for working with real data. Google has different types of questions that can be implemented on a questionnaire. Once the questionnaire is developed it can be sent via email. The collected data is stored directly onto a spreadsheet. It can then be viewed as simple graphics, or we can apply advanced statistical techniques onto the spreadsheet. Google Docs were also considered by students as easy to use (85%), and all the students (100%) were confident of the usefulness of Google Forms.

How must we adapt the Instructional Design?

- As we can see from the results (figure 5), videocasting was a useful activity in order to enhance their learning (75%) and improve social relations within students (80%).

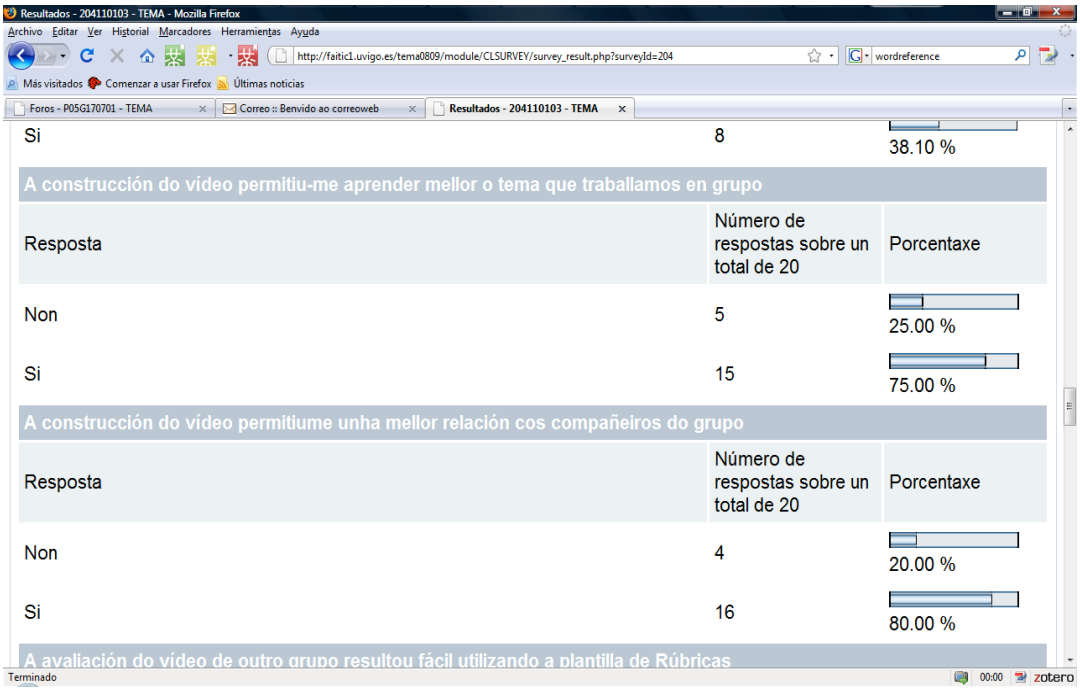

Figure 5. Better learning and relationship with other fellows

- Students confirm that it was very easy to use pre-defined rubrics in order to assess the work from other fellows (95.24%).
- It was very successful to introduce group peer assessment and 100% of the students were in favor of taking into account every work they do for their learning.
- Personal working activities gave the students the opportunity to be responsible for their learning (95.24%). All students (100%) thought they have to be responsible in their learning process.

CONCLUSION AND FINAL COMMENTS

The use of technologies can promote, in both small and large classes, the knowledge and understanding of statistics in an environment that, although tailored for each student, encourages the student to interact with his/her classmates, creating a vivid environment that enhances their learning potential.

The teacher must be aware of the specific needs of his/her students in order to modify the learning process. New social tools allow students to be responsible for every aspect of their learning when collaborating with other students in either learning, tutoring and/or assessing. These are intuitive tools in which they do not need a period of time for their specific learning, thus leaving the important role of planning the right activities and moderating them to the teacher, guaranteeing that the objectives are achieved by all students.

Future work is needed in properly adapting these tools for learning and teaching statistics. Efforts must focus on designing learning paths where students can interact with each other and teachers can supervise the entire process. Social networks, such as Facebook, may play an important role in this approach.

The Internet challenges teachers' creativity with new tools such as Google Forms, Google Analytics, Google Data Search, Gap Minder, among others, creating an excellent environment for applying statistics via the use of real data.

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