USING APPLETS FOR TRAINING STATISTICS WITH FUTURE PRIMARY TEACHERS

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In recent years, statistics has been recognised as a basic component of citizenship education and its incorporation into school curricula in various countries confirm the importance of learning statistics. Nowadays, several resources are available online, but their uses within classes may vary depending on the use teacher devises for them, therefore a critical analysis of these tools is needed. In this paper, we present a model for the analysis of statistical applets that might promote training statistics among primary teachers, thus emphasising their didactical purposes. This past school year (2011/2012), an applets selection – as statistical teaching tools – was used for training primary teachers and the model was introduced in their classes. We will only present the model and the report from one of the student groups in this paper.

INTRODUCTION

Primary teachers (teachers of pupils aged from 6 to 12) must be prepared to teach statistics from the official programmes and adequately educate their students. Realistically, this would create the need to include statistics education in the curriculum of future teachers, including contents and statistical literacy, in order to allow the development of students as fully literate citizens. In our own work (Estrada, Batanero, & Fortuny, 2004), we have already found conceptual errors in elementary concepts such as mean, median and mode, outliers, standard deviation and sampling.

This brought to our attention the need to rethink teaching methods. Given that statistics is one of the subjects where technologies had a major impact (Contreras, Martins, Estrada, & Batanero, 2011), we thought that we may use some of the available Internet resources – the applets – in our classes. It was thought that, due to their characteristics, they may enable us to develop a different approach to the statistical concepts. Thus, we agree with Anderson-Cook and Dorai-Raj (2003) who state: "We believe that the applets will be an easily accessible tool (…) to help students gain a better working understanding of the concepts". In our previous work (Nascimento & Martins, 2007; Nascimento & Martins, 2008), we have already used statistical applets with Portuguese university students, as homework, in order to make them reflect about the statistical use of their (mis)concepts and help them gain a better understanding of how to work with them. Nevertheless, future primary teachers should have the opportunity to learn how to use applets as technological resources in statistical contexts, and attention should also be paid to the appropriate use of applets in the classroom.

In this work, we present the first version of a model developed in the "Applemat Project" that enables future teachers to conduct a careful didactical analysis, with special emphasis on its utility in their future elementary classrooms. We also present an example of its use, devised by one group of students, and a table with the links of the applets used by the all other groups, arranged by subjects and school year.

APPLETS AND TRAINING STATISTICS WITH FUTURE PRIMARY TEACHERS

In the professional development of teachers, ICT acts as a semiotic mediator that may change the epistemic configuration of the mathematics learning process (Font & Godino, 2006). However, Giménez (2004) states the teachers do not usually use these resources because they do not know their possibilities and limitations. The technological resources, namely the applets, also possess the conditions for didactic suitability, defined by Godino, Wilhelmi, and Bencomo (2005) as the articulation of the following five components:

- Epistemic or mathematical suitability: representativeness of institutionally implemented (or intended) meaning as regards the reference meaning previously defined.
- Cognitive suitability: extent to which the institutionally implemented (or intended) meanings are attainable by the students and the overlap of the personal meanings achieved by them are those intended by the teacher.
- Interactive suitability: extent to which the didactical configurations and trajectories allow to identify and solve semiotic conflicts that might occur during the teaching process.
- Media/Resources suitability: availability and adequacy of material and temporal resources needed to develop the teaching and learning process.
- Emotional suitability: the students' involvement (interest, motivation...) in the study process.

Due to the availability of different statistical resources on the Internet, we think that teachers' training should introduce and promote the use of these ICT resources, specifically the applets, to help future teachers in recognising their value and applicability in elementary school classrooms. More generally, Tishkovskaya and Lancaster (2012) discuss the following:

> Probably, the most common way to use information technology to enhance teaching materials in mathematics and statistics has been to add statistics applet illustrations letting students experiment with mathematical statements. Some of these illustrations are very sophisticated and valuable new elements in instruction (…) which can be accessed over the Web and used for the purpose of statistics education.

Most of the statistical applets found are devised to show contents. In Callis' (2007) view, the applets focus on very specific contents in which the user can manipulate some windows within the same concept simply by using the mouse. Frequently, they are used to reproduce the real manipulations, to understand statistical terms and expressions, as well as to promote the generalisation of the statistical concept.

According to Powers and Blubaugh (2005), "teachers who are able to use today's technology in the classroom will be prepared to learn and utilise tomorrow's technology". More specifically, Díaz and de la Fuente (2005) determine that using applets for teaching statistics and probability increases students' motivation for the subject because they present the concepts in a more attractive way and also enable them to play a more active role in their own learning. Taking these aspects into account, it is important that the teacher considers how to use these resources effectively. So, using the applets, as well as doing their didactical analysis, may help the future teachers in the statistics learning process. In the prospective teachers' training, the methodological techniques should be implemented to give them the incentive to incorporate different types of practices into their training. This is the scope of the version of the model that we present here.

METHOD

The first approach to the model involved an answer to the question as how the future teachers should conduct the didactical analysis of the applets – as a teaching tool. This approach was developed within the "Applemat Project", as part of the "Teacher Innovation Group" (TIG). TIG group was coordinated by J. Giménez from 2006-2007 and received funds from the Catalonia Government. This working group had experienced university teachers from different areas – Analysis, Geometry, Statistics, etc. – that felt the need to improve the ICT use in the university classrooms of prospective teachers. The model was a first attempt to standardise the didactical analysis for all the scientific areas that the university students are required to know. In the two years, TIG elements viewed the components described as conditions for didactic suitability and developed the model with three different sections. In the first section, the resource is described and its possible use in elementary classes is discussed. As well, in this section, the height of the five components is higher regarding the epistemic suitability than the cognitive suitability and the emotional suitability. In the second section, the applet is devised as a teacher training tool in order to manage during teachers training university classes. Furthermore, in this second section, the height of the five components is distributed amongst all of them. Finally, in the third section, the possible improvements and extensions of the applet are proposed. Also, the height of the five components is distributed amongst all of them. This model's details are presented in Table 1, below.

Section 1. Applet analysis and possibilities	Section 2. Management and use in class for teachers' training	Section 3. Applet improvements and extensions
1.1. Applet description 1.2. Analysis and uses in	2.1. Goals 2.2. Developed professional skills	3.1. Applet improvements or extensions

primary class a. How may we use it in the class? b. Previous knowledge and contents required c. Limitations d. Techniques of use e. Other contents that may be incorporated into in the class: computations and measure	2.3. Transfer of learning a. Initial problematic situation b. Previous knowledge reinforcement c. Using the applet	3.2. Other learning possibilities 3.3. Alternative materials' advantages and disadvantages

Table 1: Model details

In our research, this model was used in the classes of Primary Teachers degree (3rd year) in a Spanish university 1st cycle (Bologna Degree) attending to the Probability and Statistics Curricular Unit in the school year of 2011/2012 (6 European Credits Transfer and accumulation System, ECTS). In this course, 123 students were divided into two classes (58 and 65 students) and they presented a total of 32 works that were carried out in groups of 3 or 4 students.

Students using the model were not familiar with the didactical analysis of applets or any other ICT resources. Thus, the university teacher presented and subsequently practised the central tendency measures with the students, before using the Illuminations mean and median applet (refereed as (C) in Table 3, below) as the learning objectives, materials, the instructional plan with the task, the discussion and questions for students were already available on the site. The students' task was then to search the Internet for different applets and select one to analyse using the model (Table 2). The basis for choose their own applet must be one or both of the subjects: their curricular unit (at the university) programme topics, or the elementary curriculum topics on data analysis or probability. Once they had selected it, students worked as a team to apply the model. Finally, they had to present a written report of their work. This analysis was delivered at the end of the curricular unit and was assessed by the teacher, representing 25% of the final grade.

AN EXAMPLE USING THE MODEL

From the 32 groups of future primary teachers, a didactical analysis using the model (Table 2) was chosen and is presented here as an example of their implementation. This work was selected based on the applet's characteristics – available for download to our own computers – and its good grade. We translated the main lines of the students' analysis regarding the "Tables and Statistical Graphs" Spanish applet (*E, in Table 3 below), and now we present it.

Section 1. Applet analysis and possibilities

1.1. Applet description: This applet is an attractive visual resource (Figure 1) that allows students to use elementary statistical techniques to obtain information about children's daily contexts including data representations, graphics and numbers, and

also allows for critical reflection of the results. This applet also helps to describe, extract and interpret the information presented in the tables or in the graphs (pies, bar charts and frequency polygons) that are based in daily problem solving. Furthermore, this applet has six folders. Each one is about one statistical chapter and we enter it by selecting one of the six persons (characters). It also contains a glossary and a guide for teachers. During its use, there is a voice that explains the activities and these explanations are also written in the applet window.


ANÀLISIS D'UN APPLET

Títol: TAULES I GRÀFICS ESTADÍSTICS

Direcció:
http://www.edu.xunta.es/espazoAbalar/sites/espazoAbalar/files/datos/1285583725/contido/index.html

Tema: ESTADÍSTICA

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1. Descripció del recurs

Aquest Applet és un recurs molt visual que permet utilitzar tècniques elementals per obtenir informació sobre fenòmens i situacions quotidianes dels infants de primària. A més a més usa tècniques per representar dades, gràfiques i numèriques, i porta a la reflexió crítica dels resultats.

També organitza dades tenint en compte un criteri de classificació i expressa el resultat en taules de freqüència i elabora polígons de freqüència i gràfics de sector a partir d'aquetes.

L'aplicació també ajuda a descriure, extraure i interpretar la informació presentada en les taules de freqüència i en les gràfiques.

Presenta les activitats en un format de resolució de problemes quotidians en els que intervé la lectura de taules i gràfiques.

L'Applet disposa de 6 apartats, cadascú corresponent a un contingut estadístic, un glossari i una guia docent. En tot moment, hi ha un assistent que va explicant les activitats tant de manera oral com escrita.

TABLES AND STATISTICAL GRAPHICS

SELECT A CHARACTER
SELECCIONA UN PERSONAJE

Figure 1: Model details in the students' work copy

1.2. Analysis and uses in elementary class

a. How may we use it in the class?

As previously discussed, this applet has six folders and each one is about one statistical chapter: data techniques of collecting and classification (4 activities); building absolute frequency tables (4 activities); frequency polygons (4 activities); building relative frequency tables (3 activities); pie charts (5 activities); reading and interpretation of statistical concepts.

b. Previous knowledge and contents required: reading double entry tables; reading coordinate axes; circular sector, including the concept of central angle measure; per cent, including knowing the per cent value of a fraction; ability to use a calculator.

c. Limitations: the applet does not have the possibility of error because if the answer is wrong, the student cannot continue the activity; the activities are not connected to each other; there is no way to change data; not all activities are for all elementary school levels.

d. Techniques of use: choosing a correct answer; put data into frequency table; checking data; arithmetic operations like addition and subtraction; reading graphs; comparing graphs or data; completing a frequency table taking into account the added data; building a table from graphs data; writing a legend; writing the title.

e. Other contents that may be incorporated into in the class: computations and measure.

Section 2. Management and use of class for teachers' training

2.1. Goals: explore the use of ICT in mathematics learning; learning to learn; development of manipulation and visualisation as a didactical procedure; potentiate the study and the understanding of frequency tables; potentiate the study and the understanding of data graphs; development of the study and its interpretations using data; learn how to teach.

2.2. Developed professional skills: analysis skills; self learning ability; critical thinking before the methodological procedures of learning; promote the cooperative work; using, applying and creating manipulative resources to learn; critical thinking.

2.3. Transfer of learning

a. Initial problematic situation: for instance, if the user chooses the sixth chapter – the baby with the bear character – data information may have different graphic types, graphics may be compared or problems with statistical graphics may be proposed. In summary, a chain of events is triggered when each person (character) is chosen.

b. Previous knowledge reinforcement: data techniques of collecting and classification; building absolute frequency tables; frequency polygons; building relative frequency tables; pie charts; reading and interpretation of statistical graphics.

c. Using the applet: using interactive learning applets as a didactical resource; different ways of representing data; valuing different ways of data presentation, reading and interpretation.

Section 3. Applet improvements and extensions

3.1. Applet improvements or extensions: if the answer is wrong, the student cannot continue the activity, so this option should be changed and the student should have the opportunity to know what their mistake was. Since the activity folders are not connected to each other, some kind of connection may be implemented in the future; devise a way to allow data changing and providing a dynamic update of the graphic.

3.2. Other learning possibilities: in these students' work, another activity folder was proposed in order to connect all the contents in the other six folders already available; create activities in the folders in order to include some with percentages; including pictograms; some more activities to reinforce students' training.

3.3. Alternative materials' advantages and disadvantages are summarised in Table 2.

Materials/Resources	Advantages	Disadvantages
Building tables and graphics with a worksheet	All computers have worksheets. Enables the discovery of how this survey tool helps students' use of statistics in their daily lives as well as in other subjects. Allows building any graphics type.	Activities must be guided by the teacher, at least in the beginning, since the software is not particularly accessible to younger students. The difficulty levels are not easily controlled by the teacher. The difficulty levels of learning are not easily controlled by the teacher.

Statistical webquest	Motivating element. Activities are based in contents and are linked between them.	If the connection between pages is lost it is impossible to finish the activity.

Table 2: Summary of the alternative materials' advantages and disadvantages

From our analysis of these students' work, we think they followed the proposed model and were able to present a critical opinion about this applet, as well as considerations that allow a better understanding of its use in the classroom. In presenting a detailed applet analysis, they provided hints as to how to improve and extend the applet possibilities. This first section shows that the students used/explored the applet in order to understand it fully. In relation to the third section of the model, the work of the students was of a good standard as they detailed improvements and extensions of the applet. The topics of subsection 2.3 were also presented well. Sections 2.1 and 2.2 were weaker, nevertheless the students attempted to offer a glimpse of the goals and a lighter view of the professional development. Overall, the group performed well using the model for the applet's didactical analysis; however some aspects require deeper analysis and written considerations.

USING OTHER APPLETS

In Table 3 we present some of the applets available on the Internet by statistical contents used by the future primary teachers' students in their works (*). Some of these applets present classical pedagogical proposals, but even those may be used for reflective thinking in the future primary teachers' training classes.

Absolute and relative frequencies
(*)http://agrega.educa.jcyl.es/visualizador1/es/pode/presentacion/visualizadorSinSecuencia/visualizar-datos.jsp
Tables and graphical representations
(*E) http://www.edu.xunta.es/espazoAbalar/espazo/repositorio/cont/tablas-y-graficos-estadisticos; (*)http://nces.ed.gov/nceskids/graphing/classic/pie.asp; (*)http://nces.ed.gov/nceskids/createagraph/default.aspx?ID=ff1641aeS879434ca66d72fflae2ae49; (*)http://www.edu365.catlprimaria/muds/socials/barreslindex.htm#; (*)http://dl.dropbox.com/44162055/manipulables/varios/tablasgraficos.swf;
Central tendency measures
(C)http://illuminations.nctm.org/LessonDetail.aspx?ID=L452; (*)http://www.juntadeandalucia.es/averroes/ceip_sanJafael/DATOS/media.swf; (*)http://ateneu.xtec.cat/wikiform/wikiexport/cursos/curriculum/inf~ri/dpma/mo; (*)http://www.librosvivos.net/smtc/homeTC.asp?TemaClave=1051; (*)http://www.juntadeandalucia.es/averroes/ceip_san_rafael/DATOS/media.swf; (*)http://odas.educarchile.cI/objetos_digitales/odas_matematicas/13promedio_moda/LearningObject/index.html
Central tendency and variability measures
(*)http://www.eduteka.org/MIImasterlinteractivate/activities/Measures/lndex.html
Chance and probability

(*)http://www.juntadeandalucia.es/averroes/carambolo/WEB%20JCLlC2/Agrega/Matematicas/Azar%20y%20probabilidad/contenido/mtll_oaOS_es/index.html;
(*)http://docentes.educacion.navarra.es/msadaall/geogebra/figu ras/azar_monedas2.htm;
(*)http://nces.ed.gov/nceskids/chances/.html;
(*)http://www.edu365.catlaulanetlintermates/9/index.html;
(*)http://clic.xtec.cat/db/act_es.jsp?id=2182;
(*)http://centros3.pntic.mec.es/cp.juan.de.la.cosa/Actividadespdimates2/01/15/04/011504.swf ;
(*)http://centros3.pntic.mec.es/cp.juan.de.la.cosa/Actividadespdimates2/01/15/03/011503.swf;
(*)http://nlvm.usu.edu/es/nav /frames _asid_305_g_4_t_5.html;
(*)http://www.edu365.cat/aulanet/intermates/4/index.html

Table 3: Some of the applets available on the Internet by statistical contents

FINAL REMARKS

The availability of the Internet resources enables statistical learning to be accomplished in a different way, using these resources as dynamics promoters. In this work, we reviewed some of the perspectives concerning the applet's uses and we presented a model that provides the guidelines for the applet's didactical analysis, within in the future primary teachers' training scope. In our own view, applets – as technological resources – and the model with its three sections, articulated the five conditions for didactic suitability, as defined by Godino, Wilhelmi, and Bencomo (2005). Concerning the epistemic or mathematical suitability, the model described was suitable to study the concepts, for instance, those of tables and graphs presented in the students' example. In general, the formal solutions are more suitable for university courses and future primary teacher training. However, for elementary school pupils, the intuitive solutions may be enough. With regards to the cognitive suitability, the resources analysed are suitable for future primary teachers. Since the interactive suitability depends mainly on how the teacher organises their work in the classroom, the students will have to work in groups in order to encourage conflicts and verbalise their occurrence. According to the fourth suitability condition, a single computer and Internet connection for each group of students will be enough. The emotional suitability is, in our view, the most appropriate of the six conditions – the students' involvement (interest, motivation ...) in the study process – and was the one that triggered the present work.

Using this model, future primary teachers were able to value applets as a didactical resource based on their own observations and manipulations. A drawback of this year's use of the model was related to the shortness of class time to promote the discussion of the written reports. As neither the teacher's student discussion was not carried out, nor the discussions amongst students, mediated by the teacher, we present an alternative proposal for future research.

We are convinced that the university students' work should continue to be carried out in small groups to promote opinions and discussion that will potentiate their critical thinking, which is essential in the building of a consensual proposal. With this work we propose a four step approach in the classroom. Firstly, we will present them this year's work so they will have a basis from which to explore the model themselves.

Secondly, they will do this year's work. Thirdly, after receiving the teacher's feedback, the students will discuss their own work in order to clarify their own concepts. Finally, in order to enhance the future teachers' didactical training for the elementary levels, they will prepare and simulate – for instance, for their colleagues – the didactical sequence in order to test it and improve it. With this approach, the applets will act as the semiotic mediator in order to change the statistics leaning process, as already underlined by Font and Godino (2006).

Although in the first teacher analysis of this school year 2011/2012 almost all work obtained good grades, we intend to further develop their analysis in a qualitative and comparative way, detailing the differences between them, as well as any written conceptual (of probability or statistics) errors made.

Finally, similarly to Contreras et al. (2011), we think that to promote an improvement of the statistical learning in elementary schools, teachers should take all these resources into consideration, particularly the applets. Therefore, these resources should be implemented into future teachers' training in similar way to the methods outlined in the current paper.

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