Paper presented at the Joint IASE/IAOS Satellite Conference "Statistics Education for Progress",
Macao, China, August 22-24, 2013 (to be published 2013 in the Conference Proceedings)

EMPLOYMENT OF NEW TECHNICAL PLATFORMS FOR INTERACTIVELY VISUALIZING STATISTICAL METHODS AND STATISTICAL DATA

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For a long time, classical media for learning and teaching, such as textbooks and teacher-centred instruction, have been complemented by e-learning components and virtual campus systems. Smartphones and tablets have impressive functionality, and are becoming ubiquitous. There is an urgent need to create resources that will run on these platforms, so that educators are providing resources that run on the tools that students actually use.

This paper illustrates how an extended media mix can broaden the scope of statistics and further education. Two complementary approaches are described. The first approach is tailor-made for desktop applications (repository containing interactive Java) whereas the second one is fully platform-independent (statistics app containing interactive learning objects based on HTLM5, CSS3 and JavaScript). The layout of the learning objects belonging to the statistics app is automatically adapted to the size of the viewing environment (responsive web design). The output of both approaches can be embedded in different educational settings, for example as a complement to face-to-face-lecturing or as a supplement to printed textbooks.

INTRODUCTION

The University of Hagen with about 85.000 students enrolled (summer 2013) is the only German State University specializing in distance teaching. For introductory statistics education, a media mix is implemented that integrates:

- printed course material distributed to students of Hagen University only, and via a publicly available textbook (Mittag 2012);
- an interactive pdf version of the course or textbook accessible within a password-protected web forum (using the open source course management system "Moodle" and an e-textbook version);
- a virtual repository containing multi-lingual Java applets for desktop application that enable visualizations of both either statistical methods and statistical data. The repository is accessible at www.fernuni-hagen.de/jmittag/repository;
- a statistics web app containing interactive learning objects in English operating on smartphones, tablets and desktops. The entrance portal can be accessed at www.fernuni-hagen.de/jmittag/app/index.html. The elements of this statistics app also aim at visualizing both methods and data;
- classical face-to-face tutoring / seminars.

Figure 1 illustrates the composition of the media mix described above. The Java applets are connected to the interactive pdf version via hyperlinks. The statistics app offers the advantage of providing supplementary direct linkage between printed material and learning objects for mobile devices via QR codes.

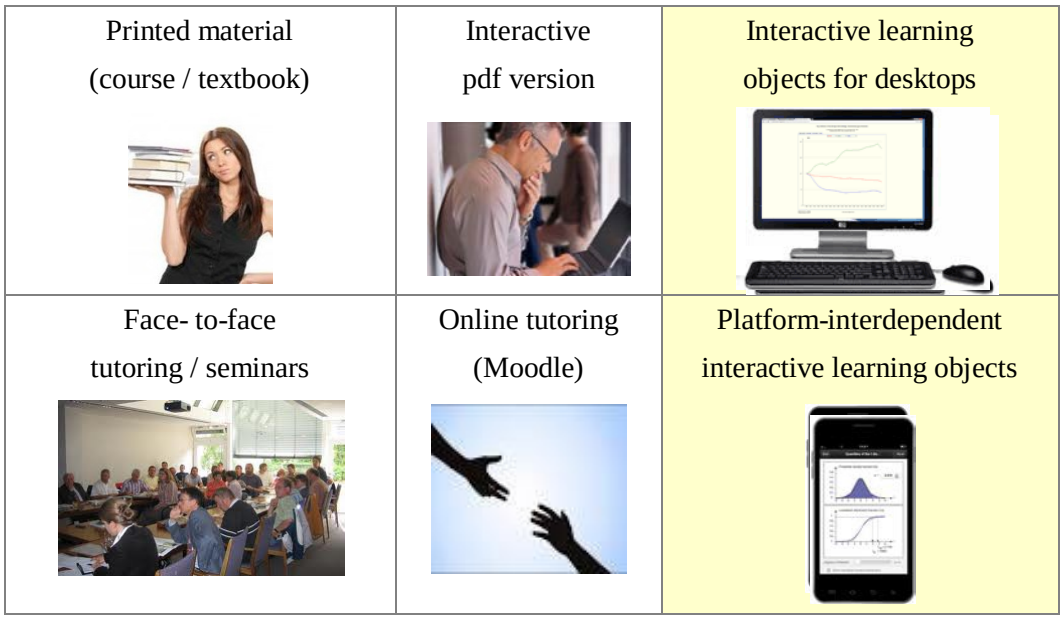

Figure 1: Media mix for introductory statistics education

This paper focuses on describing and comparing in detail the components of the media mix presented in the last column of Figure 1. Special attention is paid to the new platform-independent objects. They create the conditions for including mobile devices into the array of technical platforms that can be made use of.

VIRTUAL REPOSITORY CONTAINING INTERACTIVE JAVA APPLETS

The electronic version of the statistics course or textbook is a hypertext that contains numerous links to Java applets developed within the period 2012-2013 in Hagen. The applets are put together in a virtual library (www.fernuni-hagen.de/jmittag/repository) containing interactive experiments visualizing either basic concepts of descriptive and inferential statistics or data sets originating from official statistics. The elements are self-contained and can hence be employed in different settings occurring in statistics education and further education. They can be used, for example, by students for self-study purposes as well by lecturers as a supplement enriching traditional teaching scenarios.

Figure 2 presents a virtual dice experiment taken from the repository. It can be deployed for motivating the use of probability models in statistics. A dice is rolled n times with changeable n. The outcome of the simulation is displayed in form of the relative frequencies and the cumulative distribution of scores (part a). The graphs are complemented by a table showing the numerical values of the relative frequencies. As an option, the model of the uniform distribution can be

inserted in order to show that the model fits the empirical findings better and better as the replication parameter *n* increases.

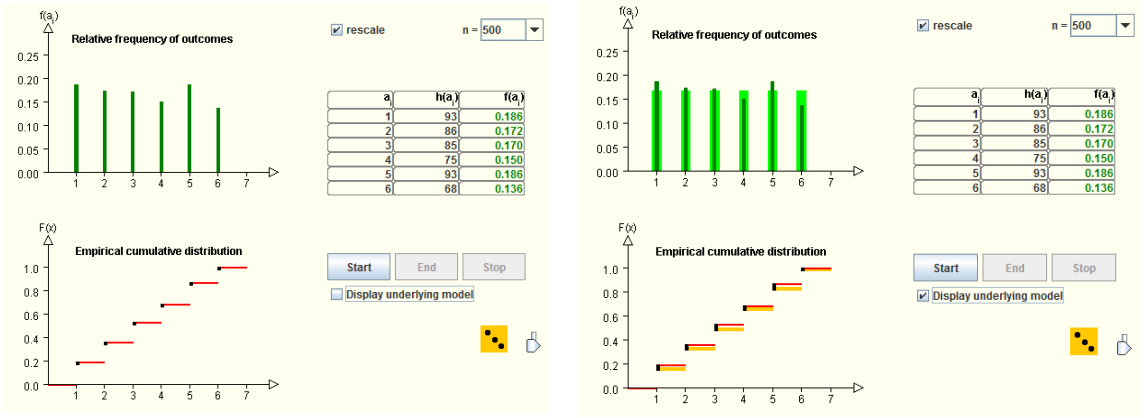

Figure 2: Modelling the outcome of a virtual dice experiment

a. Empirical distribution of scores b. Empirical and theoretical distribution

The Java applets are designed so that screen text is minimized. This characteristic facilitates translation into other languages. For the time being, all applets are available in German and English and some are available in Japanese and Spanish. Figure 3 presents an applet in Spanish dealing with the binomial distribution (part a) and another one in Japanese visualizing quantiles of the *t* distribution (part b).

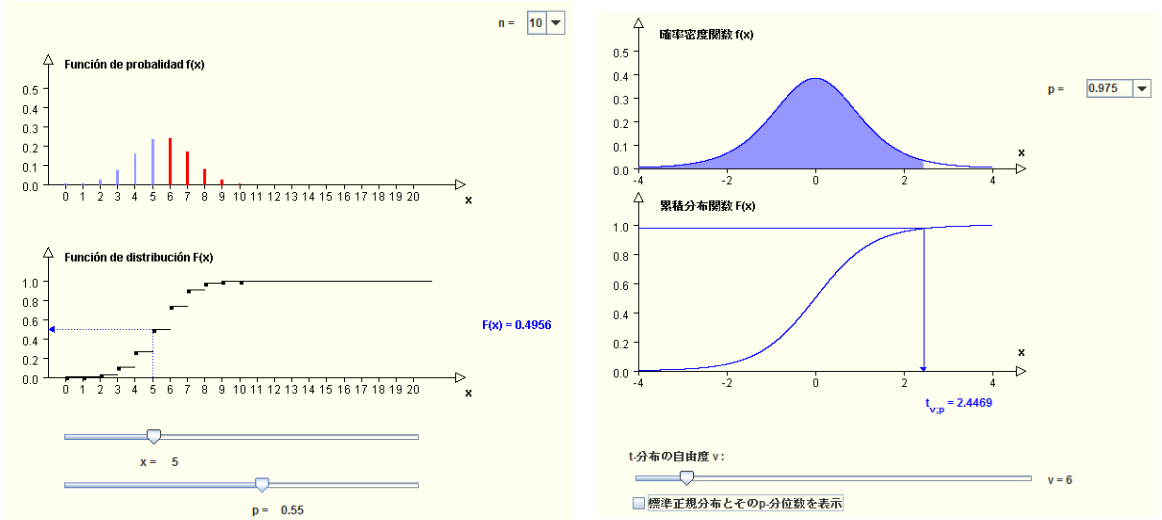

Figure 3: Different languages versions of Java applets

a. Binomial distribution (Spanish) b. Quantiles of the t distribution (Japanese)

Figure 4 provides an example of an element of the repository that aims at visualizing data from official statistics. The data refer to greenhouse gas emissions in 27 European countries during the period 1990 – 2009. The user is able to look at the data for all countries for a fixed point of time or at data for a few user-selected countries for the whole period. The data measured are relative

to the national levels which is set to 100. Different graphical tools can be used to display the data (time series graphs, boxplots, and bar charts ordered by country code or by length of the bars).

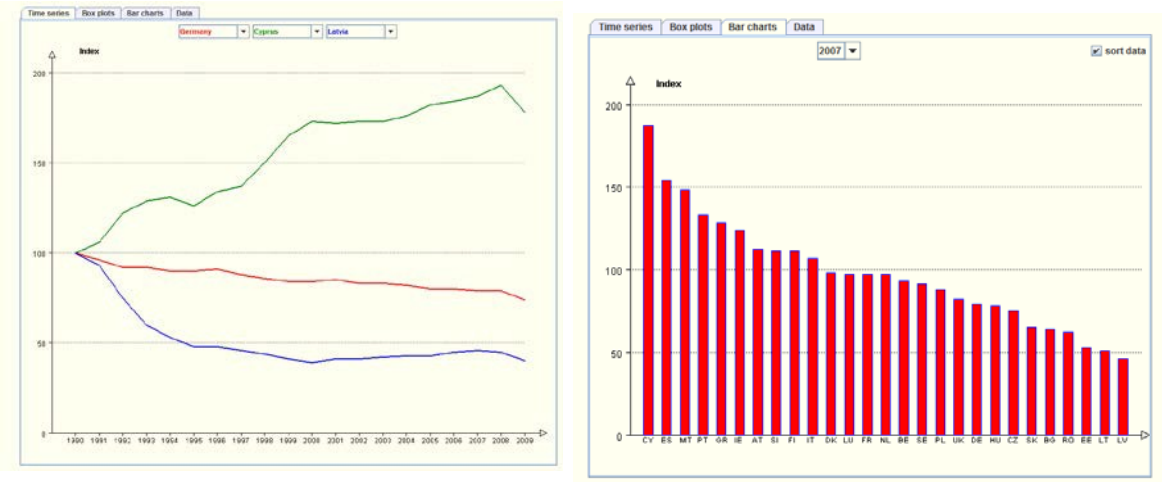

Figure 4: Java applet visualizing data (relative to 1990) on greenhouse gas emissions in Europe

a. Time series for a user-defined subset of countries b. Bar chart for a fixed year (data sorted according to size)

A PLATFORM-INDEPENDENT STATISTICS APP

The elements of the virtual repository work well on any desktop but they cannot be employed on smartphones or tablets. In view of the fact that the market penetration of mobile devices is very high, and virtually every student possesses at least a smartphone, the desirability of creating software that runs on these platforms is obvious. Another drawback of Java, apart from the lack of platform-independence, is the set of warning messages related to running Java programs that arise because of the security vulnerabilities of plugins. Oracle is working since early 2013 on fixing these bugs.

In order avoid security warning messages unsettling the user and, more important, to get rid of platform-dependence, a project has been launched that aims at reprogramming the interactive learning objects and at taking the physical limitations of mobile devices into account. Instead of Java, HTML5, CSS3 and JavaScript was employed (see Murray 2013 for details related to these Web tools). A responsive web design approach was chosen to exploit the screen size of the different technical platforms effectively. Analogous to the repository of Java applets, the goal was to develop an open web app containing interactive experiments visualizing methods applied in descriptive or inferential statistics and as presenting well selected data sets from official statistics. The app is now ready for online and, after first activation of the experiments, for offline use (via application cache).

Figure 5 presents the entrance portal of the web app after retrieval from a smartphone (part a) or tablet (part b). The app is accessible via www.fernuni-hagen.de/jmittag/app/index.html.
It currently only contains learning objects related to probability theory and inferential statistics (marked in black and white in Figure 5). Learning objects covering descriptive statistics and data visualization (still in grey) are under preparation.

Figure 5: Entrance portal of a platform-independent statistics app

a. Smartphone view b. Tablet view

Figure 6 shows interactive learning objects representing the counterparts to the English versions of the two learning objects displayed in Figure 3. Again, the use of the experiments is self-explanatory. The new elements were introduced to the lay public by presenting them on the "Year of Statistics 2013" web page (German version, http://www.statistik2013.de/).

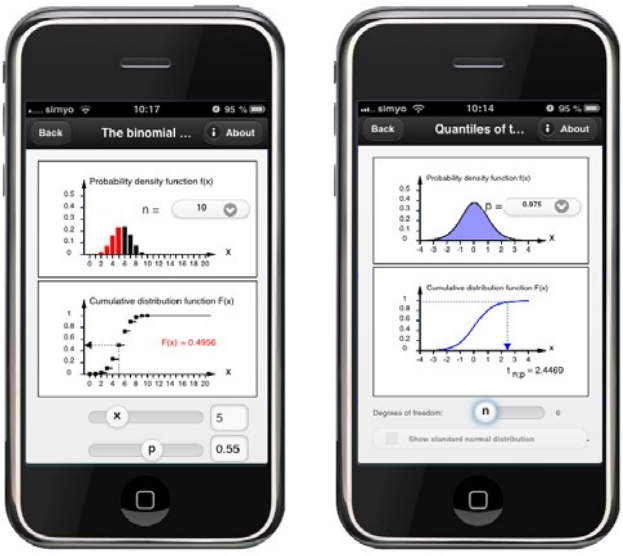

Figure 6: Platform-independent learning objects

a. Binomial distribution b. Quantiles of the t distribution

The employment of learning objects operating on mobile devices opens up the option to connect printed material and interactive experiments via QR codes. At the University of Hagen, this linkage has already been implemented for the introductory statistics course. Figure 7 shows three QR-Codes providing direct access to the entrance portal or to the interactive learning objects presented in Figure 6.

Figure 7: Quick response codes providing access to interactive experiments

a. Entrance portal b. Binomial distribution c. Quantiles of the t distribution

OUTLOOK

The next step to carry out for the statistics app will be the implementation of learning objects addressing basic concepts applied in descriptive statistics and as well learning objects interactively visualizing selected data sets from official statistics. A related development is described by Ridgway and Smith (2013). Furthermore, the coverage of further languages will be tackled. Finally, all learning objects will be embedded in open educational resources such as SOCR (Statistics Online Computational Resource) or CAUSE (Consortium for the Advancement of Undergraduate Statistics Education) in order to encourage and promote the shared employment of sophisticated educational tools.

NOTE AND ACKNOWLEDGEMENTS

The picture in Figure 1 symbolizing e-tutoring stems from the MIT Office of Minority Education. The authors are indebted to Jim Ridgway, University of Durham, United Kingdom, for valuable suggestions related to this paper, and to Sandro Mengel, Center for Media and IT at the University of Hagen, Germany, for conceptional advice.

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