EXPANDING THE MEDIA MIX IN STATISTICS EDUCATION THROUGH PLATFORM-INDEPENDENT AND INTERACTIVE LEARNING OBJECTS

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ABSTRACT

The ubiquity of mobile devices demands the exploitation of their potentials in distance and face-to-face teaching, as well for complementing textbooks in printed or electronic format. There is a strong need to develop innovative resources that open up new dimensions of learning and teaching through interactive and platform-independent content.
This paper presents such a resource for statistics education and vocational training. It is about a new, award-winning web app that is already employed world-wide in different educational settings, for example at universities within traditional statistics courses or online campus systems.

KEYWORDS

Statistics education, platform-independent learning objects, interactive visualization

1. INTRODUCTION

Nowadays, education at universities is represented by a media mix embracing classical media, such as face-to-face teaching and printed textbooks, and online components, such as e-books and online material stored within e-learning management systems. Learning content operating on mobile devices is increasingly complementing the media mix. However, learning content designed for mobile devices is usually far from fully exploiting its potentials. A multitude of apps designed for tablets and smartphones provide navigation tools supporting queries or access to social networks but apps providing user-controlled and immediate visualization of theoretical concepts are still rare.

Interactive visualization is particularly useful for teaching and learning mathematics and statistics (see Günster et al, 2013). These are sciences where formulae or data, and graphs representing the formulae or data, play an important role. Today, mathematical and statistical literacy are considered in many occupational groups as key qualifications for employability. Especially, the importance of statistical literacy is more and more recognized. This is due to the fact that management decisions at the shop-floor and other areas are increasingly based on statistical arguments ("evidence-based decision-making").

Hence, these factors suggest starting with the design of an app that facilitates the understanding of basic statistical methods and models. The app presented in this paper contains a set of self-contained interactive learning objects. The set is split up into three sub-sets. Two of these are dedicated to visualizing statistical methods and models related to descriptive and inferential statistics that are part of every introductory statistics course or textbook. The user is able to "try out" basic statistical concepts through interactive visualization.

The third sub-set of learning objects is still under development and at present only contains three learning objects. It enables the user to visually explore selected data sets by applying different graphical tools without being confronted with information overload. The data are from Eurostat, the European Statistical Office (Eurostat) in Luxembourg, and refer to the EU Member States. They cover topics that are of great interest and relevance not only for specialists but also for the lay public.

The overall goal of the app was to expand the currently applied blended-learning approaches in statistics education and further education. The existing media mix is complemented by user-friendly and platform-independent environments for interactive visualization of statistical methods or models and selected data sets

from official statistics. Hence, at last the app aims at promoting statistical literacy through providing innovative learning objects supporting the understanding of statistical theory and enabling user-controlled exploration of selected and relevant data sets from official statistics.

2. DESIGN PRINCIPLES AND EXEMPLIFICATION

2.1 Design Ideas Applied By Developing the App

The app presented in this paper is accessible for free at www.fernuni-hagen.de/jmittag/app. It is employed by students for self-study purposes, by lecturers in face-to-face teaching scenarios and as well as a supplement to introductory statistics textbooks. In order to facilitate world-wide use and to ensure usability in very different educational settings, the following design principles have been applied:

- *Stressing visualization:* All learning objects emphasize visual and interactive communication of statistical methods or data. Formulae are avoided because notation in statistics is not fully internationally uniform. The theoretical background needs to be provided by a teacher or a textbook.
- *Use of self-contained learning objects:* The learning objects are "light" and self-contained (independent "micro-learning worlds"). The granularity facilitates the embedment into different learning scenarios.
- *Use of English:* Text appearing on the screen is in English which is understood around the world. This furthers use in all continents and as well international co-operation through joint employment of innovative learning content.
- *Self-explaining navigation:* The learning objects are transparent and self-explaining. This implies that instructions for navigation are dispensable.
- *Minimizing textual information*: Text appearing on the screen is minimized in order to facilitate translation into other languages and as well the maintenance of the learning objects.
- *Platform-independence*: The app operates on all mobile devices (iOS, Android) and on all desktops. In order to avoid the access to the app via different app stores, the app is designed as a web app. After first online use of the app, it is stored in the internal cache and can also be used offline. For mobile devices, touch functionalities are incorporated whereas for desktops all functionalities of the mouse can be used.
- *Responsive web design*: The display of learning objects needs to automatically take the size of the screen into account. Hence, the size of a graph increases when switching to a device with larger screen. When using mobile devices, the learning objects can be displayed in landscape and as well in vertical format.
- *Avoiding information overload:* Learning objects presenting data do not present all data simultaneously. Instead of this, the user is enabled to select and visually present different sub-sets of the data. This makes it easier to discover messages behind the data or striking features.

2.2 Examples Illustrating the Implementation of the Design Ideas

Figure 1 exemplarily illustrates how the goals of communicating content via interactive visualization and creating self-contained and self-explaining learning objects have been achieved. The learning object exclusively deals with the binomial distribution. The binomial distribution represents one of the most employed models for discrete random variables. Nowadays, this model is already taught at secondary schools. The navigation of the object is easy and obvious. The user can change the parameters n und p of the model und as well the argument variable x of the probability density function f(x) and the cumulative distribution function F(x). The Figure shows the result for two different choices of the triple (n, p, x). For each triple, the graphs of f(x) and F(x) are shown and the value for F(x), with x as chosen by the user, is displayed in red. Introductory statistics textbooks typically contain in an appendix only tables for the values F(x), whereas the learning object also reveals the meaning of such values. The values marked in red result by summing up the length of the bars in red of the upper graphs.

Figure 1. Learning object "The binomial distribution" (in English), displayed on a smartphone

Figure 2 is dedicated to the standard normal distribution, the most used model for continuous random variables. This model can again be described by the probability density function and the cumulative density function. The latter function has a special notation Φ(x) instead of F(x), due to the paramount importance of the standard normal distribution. When employing this learning object, the user is able to determine and to change the value of the argument variable x. The Figure displays the resulting value of the cumulative distribution function for two different choices of x. The values Φ(x) are tabulated in any introductory textbook, but again, the learning object provides an interpretation of the meaning of such values. The displayed values Φ(x) correspond to the coloured area below the graph of the probability density function.

Figure 2. Learning object "The standard normal distribution" (in English and Japanese), displayed on a smartphone

The second part of Figure 2 illustrates how the minimization of text on the screen and the granularity of the learning objects facilitates translation into other languages and its embedment into different contexts. For implementing a Japanese version of the learning object dealing with the standard normal distribution, only the title of the object and the label of both vertical axis needed to be exchanged. Japanese versions of different learning project of the app are already in use within the ongoing JINSE project (*J*apanese *I*nter-University *N*etwork for *S*tatistics *E*ducation; see *Takemura et al, 2013*).

Figure 3 shows again the interactive learning object dealing with the standard normal distribution, now retrieved from a tablet. The responsive web design ensures that the visualization of both graphs is adapted to the screen size. The simultaneous usability of all learning objects on mobile devices desktops requires the incorporation of navigation approaches that are typical for both types of hardware: availability of touch functionalities for smartphones and tablets as shown in Figure 3 and employability of the mouse for desktops.

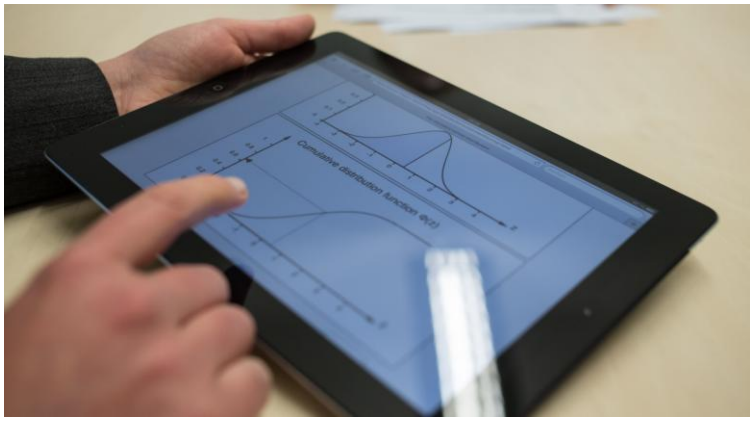

Figure 3. Learning object "The standard normal distribution" in use on a tablet (English version)

Figure 4 illustrates how information overload is avoided when interactively exploring a data set. The data in play are official data from Eurostat for the current European Member States. The data set refers to 28 countries and covers the period 1990 – 2012. The national emission levels for 1990 are defined as 100. Cutting down the relative levels by 2020 from 100 to 80 represents one of the key targets of the so-called *Europe 2020 Strategy* of the European Commission.

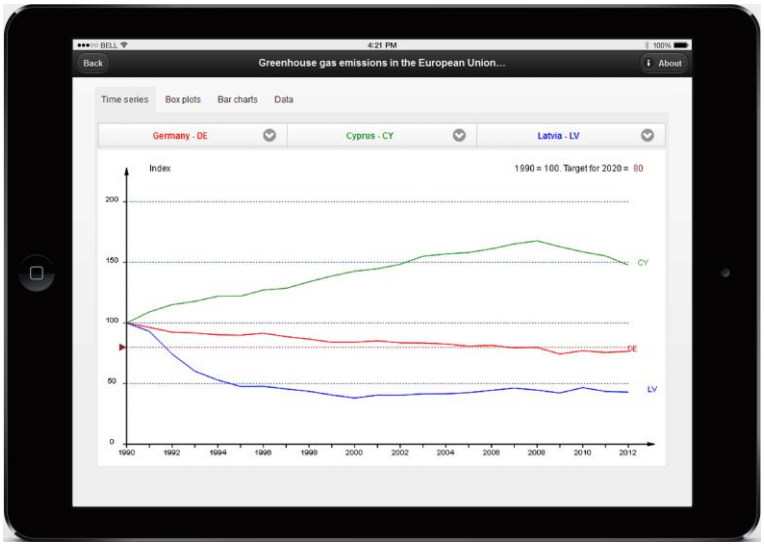

Figure 4. Learning object "Greenhouse gas emissions in the EU-28" (in English), displayed on a tablet

The learning object dealing with European data on greenhouse gas emissions enables the user to visually judge the progress made by the individual Member States so far, on the basis of all data available through Eurostat. Instead of simultaneously presenting time series graphs for all countries, the design allows the display of time series graphs for the whole period 1990 – 2012, but only for three user-selected Member States. The design also allows the comparison via bar charts for all 28 countries, but in this case only for one year that again can be chosen by the user. One immediately notices, amongst others, that Cyprus failed and Latvia succeeded hitherto in decreasing the national greenhouse gas emission level measured in 1990.

Other learning objects of the app aiming at user-controlled data exploration of relevant data from official statistics refer to life expectancy of newborn with breakdown by sex or to employment rates in the EU-28.

3. CURRENT USE OF THE APP, CONCLUSIONS AND OUTLOOK

For the time being, the app is employed at the University of Hagen, the only German State University specialized in distance teaching, within an introductory statistics course. The course is available as textbook and e-book (Mittag, 2014). The printed book version contains QR codes providing direct access to the individual learning objects of the app.

The learning objects of the app are employed as well outside Germany. Due to the functionalities of Google Analytics, it is possible to monitor world-wide how often, at which location and with which technical device the different learning objects are used. Currently, the app or its components have been implemented in about 20 countries, although the purpose and context of use is usually unknown. There are a few exceptions such as the inclusion of interactive elements translated into Japanese into the educational project JINSE. This ongoing project involves eight Japanese universities.

Since January 2015, a modified and expanded German version of the app is accessible for free via www.hamburger-fh.de/statistik-app. The German version contains short operational instructions for all learning objects. It is intended for use in Germany and German-speaking regions not only for introductory statistics education at universities, but at secondary schools and colleges as well.

A potential application of the learning objects dedicated to interactive data visualization is their use in the new field of data journalism. Here, environments for dynamic or interactive data visualization are embedded into a story referring to the data. The results are data-driven stories which are increasingly published in leading online journals. The reader of an article written in this new format is thus able to explore the data and to check and comprehend the arguments of the story around the data.

The statistics app presented in this paper is globally the first platform-independent app designed for introductory statistics education. It stresses interactive visualization of basic statistical concepts and user-controlled exploration of selected data sets from official statistics. In the months to come, the goal is to complement the learning objects developed so far by further objects, in co-operation with international partners. The information on web traffic for the app gained via Google Analytics shows a continuously increasing interest in the tool. The next step will be to systematically collect user feedback and suggestions for further improvement, for example by employing questionnaires evaluating user satisfaction.

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