

Emphasizing Visualization and Activities in Teaching Introductory Statistics by Interactive Multimedia

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Statistics has a rather poor image in society. Students at colleges or universities coming in touch with this science get the impression that Statistics is a boring discipline which mainly deals with collecting and presenting endless rows of numerical data. On the other hand everyone is confronted with Statistics every day, for example with the most recent unemployment data, with visualized stock market developments, with the analysis of sports results or with HIV rate forecasts for African countries. Statistics is part of everyone's life. The problem is that the average user of Statistics does not suspect that the exploratory analysis of data and the statistical inference from data could be an exciting voyage of discovery.

Goals and target users of the multimedia project

Motivation or even enthusiasm for a subject can more easily develop if the learner gets the chance to actively take part in shaping the learning process and if there is an interface between the subject and the learner's interest. Nowadays these preconditions could be ideally met by self-driven, computer-based and Web-supported learning. Modern educational software offers a unique opportunity to considerably improve the quality and efficiency of teaching and even the image of a science in society.

The truth of this statement is being amply demonstrated for the science "Statistics" by developing a multimedia educational software "Introductory Statistics" within the framework of a future university network. The German State of North-Rhine Westphalia provided the necessary funds for this project. Statistics seems to be particularly suitable for illustrating the new dimensions of multimedia-based learning. The project, started in January 1998, aims at establishing modularly structured software for improving statistical education at colleges and at universities as well as supporting further education on the shop floor. The software is designed for the individual learner and, at the same time, for the teacher who might use it in organizing lectures or group-based training. A first part "Descriptive Statistics and Explanatory Data Analysis" has now been completed. A second module is in preparation, dealing with "Probability and Distribution Models for Random Variables". The illustrations mentioned in this paper refer to the first part of the software.

Didactical guidelines

Print media and teacher-centred instruction have their own specific advantages and disadvantages compared with PC-supported learning. For large amounts of text a book would be the most suitable medium for presentation – nobody likes reading 1000 pages on a screen. A distinguishing feature of excellent teaching software is that it makes full use of those of its facilities that surmount the limitations of traditional teaching media. Good software focuses on exploiting the potential of added value compared to established modes of instruction.

These considerations led to the following didactical guidelines for designing a multimedia course "Introductory Statistics":

- *Emphasizing interactive and experiment-driven learning*

The software aims at enabling students to experience basic statistical principles by means of interactive experiments.

- *Visualization of concepts*

Basic concepts and knotty teaching material can be more efficiently communicated by stressing visualization and animation. Video clips with examples from practice may also contribute to reducing the formal abstractness of Statistics and to making application contexts more visible.

- *Accentuating interdisciplinarity*

Statistics fulfils an important service function for many sciences. In this way it connects quite different disciplines, say Medicine, Psychology, Economics and Social Sciences or Engineering. This wide range of applications can be clearly pointed out in a multimedia course by means of suitable examples.

- *Use of the latest information*

The multimedia software “Introductory Statistics” offers here and there the option to download data from the Internet and to immediately work with these data. The learner may, for example, download the most recent official data from the job market presented by the German Federal Statistical Office and calculate a geometric mean based on these data. Beyond this it is planned to offer updates via the Web for complete screen pages in case of later revision.

- *Promoting global learning*

A suitably designed multimedia approach also offers the chance to link to interesting Web-sites containing information complementary to the main subjects. The learner may, for example, first look at visualized population data for different nations. After this he might be sufficiently motivated to ask for additional sources and to glance with anxiety at the world population clock of the US Bureau of the Census or to jump to detailed information related to the decrease of expected life time for newborn children in countries hardest affected by HIV. Such options are more than gadgets. They may considerably contribute to generating or to reinforcing intrinsic motivation and to illustrate the relevance of the subjects dealt with.

- *Supporting customized learning and teaching*

The widely-defined target group implies a course design which takes very different individual needs into account. Consequently the course has several learning levels. The first level contains basic text and a visualized summary. The second level includes background theory, animated examples and interactive exercises. The third level comprises “expert” knowledge. An encyclopedia-like glossary is connected with the first level via links. The learner may choose a standard or customized learning path. He may go through all learning levels while going first through the course and confine on the main level while repeating the subject. The teacher has the option to copy isolated elements of the software (animations or visualized proofs) and to integrate these elements into a self-defined context, for example, into a PowerPoint presentation.

- *Improving communication*

The multimedia course also aims at improving the communication between learner and teacher as well as among the learner community. E-mail connection, a course-related newsgroup and, in the future, Internet-based assignments may contribute to achieving this aim.

Technical aspects

The multimedia course “Introductory Statistics” is designed in the form of an animated textbook with uniform bipartite layout of the screen pages.

Figure 1: ¹ Initial state of a screen page

The subject and the communication functions are made available through an Internet browser. The course contents are in HTML format. Numerous interactive exercises are integrated as Java applets. The learning process is predominantly organized in the “offline” mode. Students with Internet access are free to switch at predefined course points to “online” learning and to download actual data or information (see figure 2).

The course aims at becoming a cornerstone of a growing “Virtual University”. Until further notice the CD ROM or DVD will be the basic storage medium. After starting the CD ROM or DVD the learner is asked whether he or she wants to download revised course sub-modules via the web (i. e. carry out a virtual update).

Illustration of the course material

Figure 1 shows the course layout. Every screen page is divided into two parts. The *right-hand half* contains the main text (first learning level). The size of this text is kept to a minimum. If the learner is interested in getting more detailed information, he may move up to the second learning level. Here he finds theoretical background, highly interactive exercises examples from different fields of application or additional information for the more advanced learner. Definitions of basic statistical terms may be found in a glossary. The glossary is accessible from the first learning level via links or course navigations functions.

The *left-hand half* is reserved for example-related graphics or animations, for the step-wise derivation of the theory behind the concepts and for performing the interactive exercises. In its basic state, the left half-hand half of the page displays a summary of the main content of the text from the first learning level. While studying the course for the first time, the learner will probably want to visit the second learning level. If one switches by simple mouse click on differently labeled buttons to this level, only the left-hand half of the screen changes. The content behind the buttons labeled “Theory”, “Example”, “Exercise” or “Expert” can be made visible before button activation by means of tool tips, i. e. very brief help texts.

Figure 2 shows the state of the screen page already presented in figure 1 after activation of a button labeled “Example” and more precisely specified text, via ‘Help’, as “Time series (stock market index)”. Students with Internet access may here switch by mouse click from off-line to on-line learning (surfing in the “open world”). In the case of figure 2 the mouse click effects fading on to a view on today’s development of the German stock market index at Frankfurt since the market opened that morning.

¹ Due to the given space restrictions two versions of this paper have been created. The version in hand suppresses the three figures mentioned in the body text. A complete version with figures is accessible via the Internet address <http://www.fernuni-hagen.de/STATISTIK/ISI99>.

Figure 2: State of a screen page after activation of an element of the second learning level

Figure 3 shows another screen page after activation of a button labeled "Exercise". Here the student is taught a basic statistical concept, in this case the Pearson approach for measuring linear correlation, by "trying it out". After mouse-conducted data point specification the program immediately displays the actual sample size, the correlation coefficient and the coordinates of the data points. Whereas a textbook could in this context only offer commentated static scatter diagrams, a multimedia approach opens completely new dimensions for statistical education. The learner may now "play" with self-generated data and study the effects. The optional sound feature supports the exploratory tour by suggesting certain activities, for example creating an outlier or modeling a non-linear relationship to observe the behaviour of the correlation measure.

Figure 3: State of a screen page after activation of an element of the second learning level

Project partnerships and information

The multimedia course "Introductory Statistics" is an interdisciplinary project involving at the *University of Hagen* the chair for Statistics and Econometrics (PD Dr. H.-J. Mittag / Dr. D. Stemann) and at the Department for Informatics a chair for Applied Computer Sciences with long experience in designing and developing multimedia software (Prof. Dr. G. Schlageter / Dr. E. Heuel / G. Nemirovski). The software evaluation and test will be supported by the chair for Statistics and Econometrics at the *University of Bochum*, Germany (Prof. Dr. M. Lösch). The University of Hagen looks for international partners interested in translating the project output and to adopting it to their specific needs. The already finished multimedia software "Descriptive Statistics and Exploratory Data Analysis" represents an excellent starting-point for a cooperation.

Information related to the project and a demo version of the first part mentioned above are available via <http://www.fernuni-hagen.de/STATISTIK>. The speed of the purely net-based demo version is unsatisfactory as far as highspeed Internet is not available. By contrast, the CD ROM or DVD based full version operates without disruptive loading periods.

RÉSUMÉ

Dans notre société la Statistique jouit d'une réputation assez mauvaise. Les étudiants qui entrent en contact avec cette science reçoivent bientôt l'impression fautive que la Statistique s'occupe prépondéramment du ramassage et de la présentation de colonnes de données sans fin. D'autre part, chacun est confronté avec la Statistique tous les jours. Le problème consiste dans le fait que l'applicateur moyen de la Statistique ne s'aperçoit pas que l'analyse exploratrice et l'inférence de données peuvent être un voyage de découverte fascinant.

L'évolution de la motivation ou même de l'enthousiasme envers une discipline est appuyé si l'on donne à l'élève ou à l'étudiant la chance d'apporter son concours à former le processus d'apprentissage et s'il y a une interface entre le sujet et l'intérêt de l'étudiant. Aujourd'hui toutes ces conditions peuvent être remplies par excellence par des programmes d'instruction interactifs et basés sur l'Internet. Le software moderne pour l'instruction offre l'occasion unique d'améliorer considérablement la qualité et l'efficacité de l'enseignement et même de changer la réputation d'une science dans la société. La validité de cette assertion est démontrée amplement pour la Statistique par un software multimédia "Statistique introductoire". Le software a pour but d'améliorer l'instruction en Statistique dans les collèges et dans les universités et aussi l'éducation permanente dans la pratique.