EMILeA-stat: A web-based learning environment in applied statistics with a focus on learning and teaching in secondary schools

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Abstract

Within the "New Media in Education Funding Programme" the German Federal Ministry of Education and Research (bmb+f) supports the project "e-stat" to develop and provide a multimedia, web-based, and interactive learning and teaching environment in applied statistics called EMILeA-stat. The structure of EMILeA-stat, its scope and objectives are sketched focussing on its use in teaching and learning statistics in secondary schools. Related contents, interactive visualizations, and didactical aspects are presented.

1. Introduction

Within the "New Media in Education Funding Programme" the German Federal Ministry of Education and Research (bmb+f) supports the project "e-stat" (project period April 2001 – March 2004) to develop and provide a multimedia, web-based, and interactive learning and teaching environment in applied statistics. It is called EMILeA-stat, which is a registered brand name.

The project was set up by 13 partners now working at eight German universities: Augsburg, Bonn, Berlin (Humboldt-University), Dortmund, Karlsruhe, Münster, Oldenburg (leading university), and Potsdam. In test and evaluation phases of EMILeA-stat other universities will be involved. The project is also supported by further partners in advice and it cooperates with economic partners such as SPSS Software, BertelsmannSpringer Science+Business Media (Springer Verlag), and MD*Tech Method & Data Technologies (XploRe-Software). Moreover, the group of associated partners who are providing additional content is still growing such that, at the present time, about 70 people are co-working in developing und

realizing the learning and teaching environment.

Sustainability has always been a main aspect of the strategy of the e-stat project. It is therefore taken into consideration by various features such as the elementary modular structure of the system or the use of standards like XML or MathML. In addition, the e-stat group has been open to people interested in supporting the project. Up to now more than 15 associated partners working at universities, schools, and business have joined the team. Furthermore, a subsequent project has already been acquired and will guarantee a successful continuation.

For more details about the project, the contents, and the technical realization of EMILeA-stat we refer to the project web page www.emilea.de, as well as to the list of references.

2. The learning and teaching environment EMILeA-stat

Statistical and quantitative thinking and acting have become fundamental skills in several branches of natural sciences, life sciences, social sciences, economics, and engineering. Models, tools, and methods, which have been developed in statistics, are applied in modelling and data analysis, e.g., in business and industry, in order to obtain decision criteria and to gain more insight into structural correlations. Nowadays, statistics plays an important role in our daily lives. Thus, statistics must be regarded as an important part of mathematical education. Owing to these various applications and the necessity of using statistical methodology in so many fields, consequences with respect to learning and teaching have to be drawn. The organization of teaching processes has to be changed: Pupils should get to know elementary and application-oriented statistics (e.g., descriptive statistics, exploratory data analysis). In German school curricular statistics is already equally mentioned to algebra, geometry and analysis but owing to a small range of teaching materials and a lack in the statistical education on the teacher's side this subject often is put in the second place when organizing the syllabus. Therefore, it is necessary that statistics and data analysis, theoretically and practically, have to become part of teachers' studies at university and at in-service training courses. Moreover, new teaching material is needed. Because of the learning goal "media competence" which is also demanded by the school curricular these materials should also train the ability to use the so called New Media. Especially for teaching statistics these technologies offer many didactical advantages.

But not only pupils have to study statistics and to develop media competence. Students of many different disciplines should be familiar with basic and advanced statistics. These goals

gave the main impact to develop EMILeA-stat

- as **one** system suitable for teaching statistics at schools, universities, and in further vocational training,
- as **one** system which supports supervised and self-directed learning, and
- as **one** system which is accessible anywhere, anytime, and for anyone.

The basic concept offers on the one hand the opportunity to tailor individual courses covering specific learning needs. On the other hand, EMILeA-stat serves as an environment for self-directed learning as well as an intelligent statistical encyclopaedia.

Basic statistical contents are presented on three levels of abstraction in order to take into account that different types of users have – owing to their individual mathematical and theoretical backgrounds – different needs. If sensible, the contents are written on

- an elementary level (presentation in a popular scientific way by assuming no or only a low previous (mathematical) knowledge),
- a basic level (like undergraduate courses in applied statistics for students, e.g., of economics, psychology, and social sciences), and
- an advanced level (containing deeper material and special topics within the broad field of statistics and applied probability).

Furthermore, user-oriented views and scenarios, which are near to real world applications, are integrated. Thereby, different teaching concepts and instructional designs are supported and the system can be seen as an innovative high-quality contribution to the learning facilities of the present and the future.

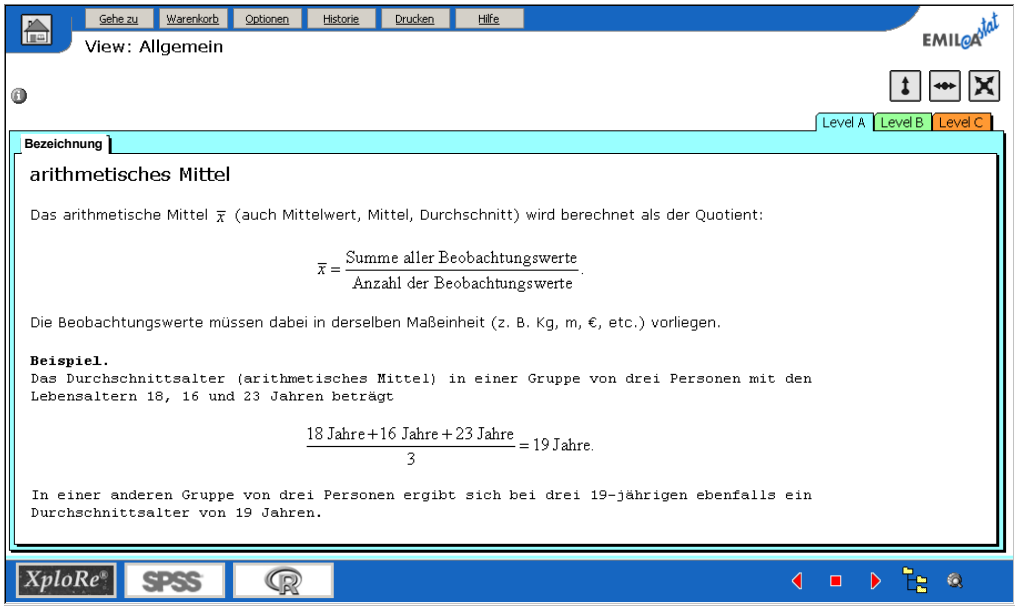


Figure 1.The graphical user interface of EMILeA-stat

The following fields and subjects of quantitative methodology are contained in EMILeA-stat: Descriptive and inductive statistics, exploratory data analysis, interactive statistics, graphical representations and methods, basic mathematics needed in statistics, probability theory, statistical methods in finance and insurance mathematics, modelling and prediction of data in financial markets, statistical methods in marketing, scenarios stock-market, productions and virtual company, experimental design, statistical quality management, business games, statistical methods in controlling, and statistical ecology.

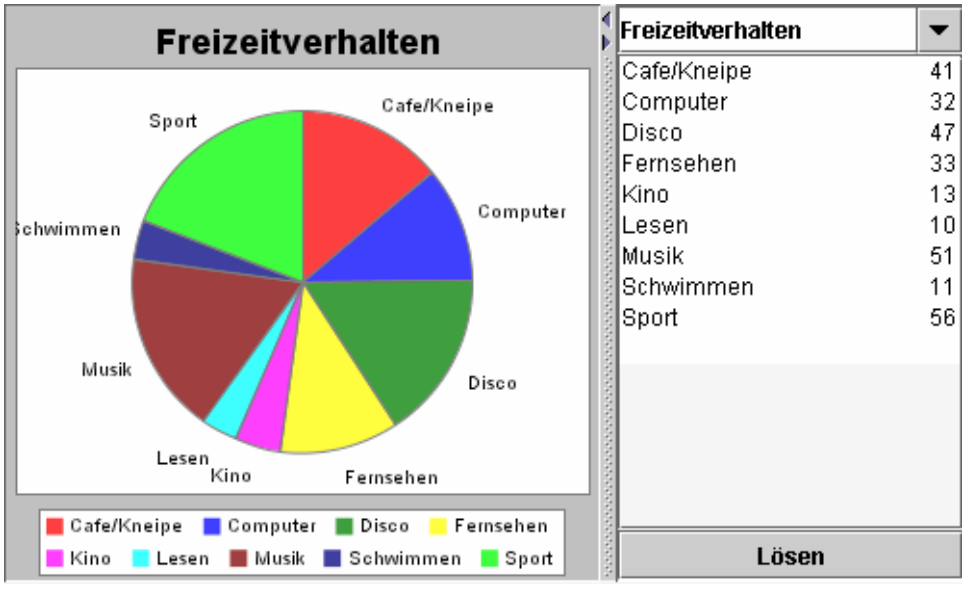


Figure 2. Interactive applet: Pie chart, level A

3. Interactive Visualizations

The support of learning and teaching by offering interactive visualizations, such as Java-Applets, throughout, is a main concept of EMILeA-stat.

Figure 3. Interactive applet: Box-Plot, level B

In the following, some examples concerning descriptive statistics and the main tools of presenting data are explained. Starting with elementary visualizations like pie charts (cf. Figure 2), bar and line graphs, box-plots (cf. Figure 3), stem-and-leaf plots, histograms, and plots of the empirical distribution function, traditional measures like mean, standard deviation, quantiles, etc. are considered as well as measures of relationships between measurement or categorical variables.

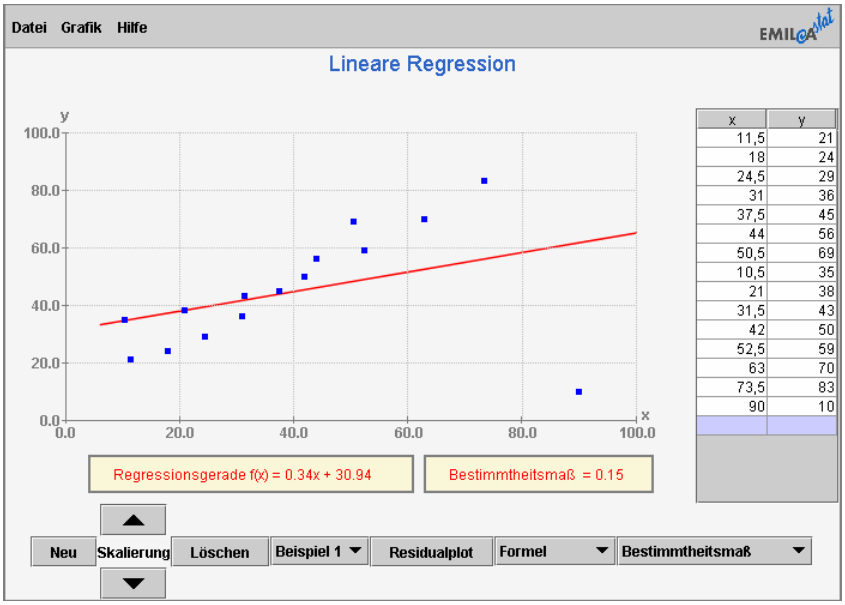
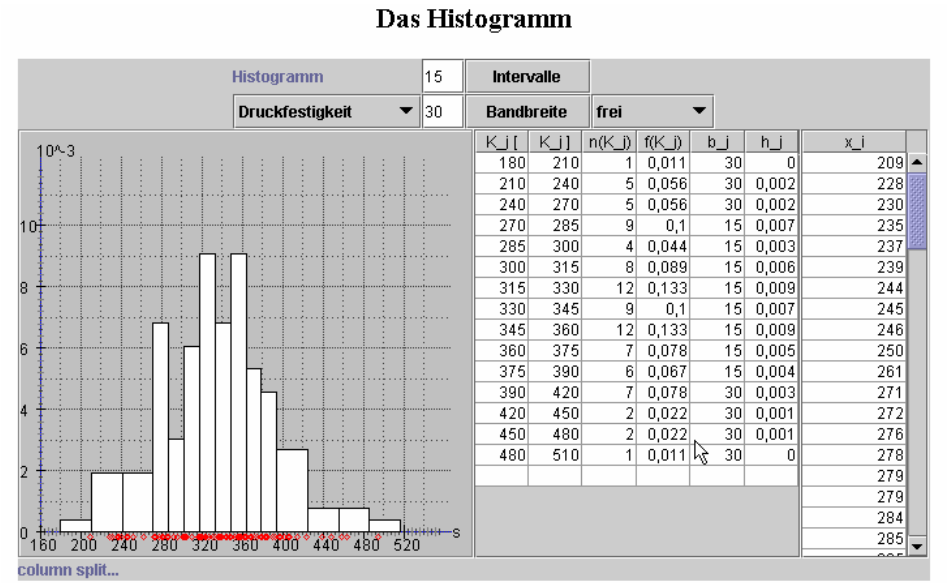


Figure 4. Interactive applet: Linear regression, level C

Finally, procedures of multivariate data analysis like cluster analysis, principal component analysis, factor analysis, and multidimensional scaling supplement the toolbox of descriptive statistics and exploratory data analysis.

Each interactive visualization is also available on three levels of abstraction. The level displayed in a course is prescribed by the teacher but the user can of course, in case of interest, switch between these versions of the applet. The elementary level A offers at least interactivity whereas on level C (advanced) the full range of functionality is accessible. The histogram applet (cf. Figure 5) provides many interactive features on level C: For instance, already included examples may be modified by adding new data points. They can be given numerically or by clicking with the right mouse button under the x-axis. Moreover, existing data values (points on the x-axis) can be moved to the right and left with the left mouse button and the



K_j [	K_j]	n(K_j)	f(K_j)	b_j	h_j	x_i
180	210	1	0,011	30	0	209
210	240	5	0,056	30	0,002	228
240	270	5	0,056	30	0,002	230
270	285	9	0,1	15	0,007	235
285	300	4	0,044	15	0,003	237
300	315	8	0,089	15	0,006	239
315	330	12	0,133	15	0,009	244
330	345	9	0,1	15	0,007	245
345	360	12	0,133	15	0,009	246
360	375	7	0,078	15	0,005	250
375	390	6	0,067	15	0,004	261
390	420	7	0,078	30	0,003	271
420	450	2	0,022	30	0,001	272
450	480	2	0,022	30	0,001	276
480	510	1	0,011	30	0	278
						279
						279
						284
						285

Figure 5. Interactive applet: Histogram, level C

axes are automatically rescaled. Each bar can be split of into two bars by clicking with the mouse into the respective bar. The endpoints of the bars can also be shifted. Furthermore, the number of bars or the length of the intervals can be specified. An optimal bandwidth may be chosen according to methods presented in the statistical literature. Finally, the numerical values for the intervals, frequencies, etc. are given in a table. On the other hand the applet can be used for representing own data, an option that is not included on level B. Moreover, the bandwidth is always equidistant on the basic level. The most restricted version, the applet on level A, offers even less interactivity: It is only possible to manipulate the given data by adding points in the graph and to choose the number of intervals.

The “user management” is standardized such that the frequent user should be able to work with a new applet easily. Instructions accompanying the graphics indicate the concept of learning by discovery enabled via the available interactivity.

4. EMILeA-stat in secondary schools

Nowadays, statistics is regarded to be an important aspect of mathematics education. Our multimedia, internet-based and active teaching and learning environment offers a new range of various perspectives on the subject matter of statistics in secondary schools. Therefore, specific courses addressing students in secondary schools are included in EMILeA-stat. Furthermore, teachers are welcome to arrange their own courses by using the available content and/or adding their own materials.

The existing students’ courses take into account various didactical aspects. In designing the

material we use authentic material, such as data from daily life environments. Different learner interests are considered and play a crucial role in the course development. We will provide an environment, which gives students the opportunity to solve statistical problems in an interactive process, which is characterized by student-directed actions. This learning process will challenge the students' cognitive and non-cognitive abilities.

These didactical criteria are integrated into the learning and teaching system in different ways: On the one hand different types of motivations for the contents are offered. This aspect plays an essential role and is realised, for example, by using simulations and different forms of visualization and verbalization. On the other hand pupils will be able to examine in a playful way their personal level of achieved knowledge. This is realised by different types of exercises such as fill-in-the-blank texts or multiple-choice tests. Furthermore, the opportunity to participate by collecting own data is offered. They are taught to take a critical look at various statistical problems and to develop a substantial data competence. The EMILeA-stat student courses are implemented as a learning environment, which provide challenging non-routine problems and supports active, self-initiated learning processes.

The courses are accompanied by additional material for teachers that offers the statistical background and didactical information. It is also part of the learning and teaching environment and therefore accessible anytime and anywhere. The statistical background material includes deeper mathematical knowledge whereas the didactical part deals with different points: It explains the didactical concept of the courses, gives practical support concerning the technical equipment and the time schedule needed and offers possibilities how to integrate the learning units into the classical curricula.

Since spring 2003 we have set up some evaluations of different courses in German secondary schools. The results of the evaluation processes are immediately considered in the development of EMILeA-stat. We will report on our experiences in a future paper.

References

E. Cramer, K. Cramer and U. Kamps (2002) e-stat: A web-based learning environment in applied statistics. In: W. Härdle and B. Rönz (Eds.) COMPSTAT 2002 – Proceedings in Computational Statistics, Physica, Heidelberg 309-314.

K. Cramer, E. Cramer and U. Kamps (2003) Die elementar-modulare Struktur der Lehr- und Lernumgebung EMILeA-stat (in German). To appear in Medien in der Wissenschaft, Waxmann, Münster.

U. Genschel, U. Gather and A. Busch (2002) EMILeA-stat: Structural and didactic aspects of teaching statistics through an internet-based, multi-medial environment. In: W. Härdle and B. Rönz (Eds.) COMPSTAT 2002 – Proceedings in Computational Statistics, Physica, Heidelberg 339-342.

L. J. Issing (2002) Instruktions-Design für Multimedia. In: L.J. Issing & P. Klimsa (Hrsg.), Informationen und Lernen mit Multimedia und Internet (3.Aufl.), BeltzPVU, Weinheim 151-176.

C. Möbus, B. Albers, S. Hartmann and J. Zurborg (2002) Intelligent WBT: Specification and architecture of the distributed, multimedia e-Learning system e-stat. In W. Härdle and B. Rönz (Eds.) COMPSTAT 2002 – Proceedings in Computational Statistics, Physica, Heidelberg, 401– 406.

C. Möbus, B. Albers, S. Hartmann, H.J. Thole and J. Zurborg (2002) Towards a specification of distributed and intelligent web based training systems. In: St. A. Cerri, G. Gouarderes and F. Paraguacu (Eds.), Intelligent Tutoring Systems, Proceedings of the 6th International Conference, ITS2002, Biarritz, France and San Sebastian, Spain, June, 2002. Springer, Berlin 291–300.

C. Mohn and D. Pfeifer (2002) e-stat: Basic stochastic finance at school level. In: W. Härdle and B. Rönz (Eds.) COMPSTAT 2002 – Proceedings in Computational Statistics, Physica, Heidelberg 321-326.

C. Pahl, P. Lipinski and K. Reiss (2002) e-stat: Web-based learning and teaching of statistics in secondary schools. In: W. Härdle and B. Rönz (Eds.) COMPSTAT 2002 – Proceedings in Computational Statistics, Physica, Heidelberg 333-338.

G. Reinmann-Rothmeier and H. Mandl (2001) Unterrichten und Lernumgebungen gestalten. In: A. Krapp and B. Weidemann, Pädagogaische Psychologie, BeltzPVU, Weinheim 601-646

P. Strittmatter and H. Niegemann (2000) Lehren und Lernen mit Medien: Eine Einführung. Wissenschaftliche Buchgesellschaft, Darmstadt.