Usability Evaluation of User Interfaces with the Computer-aided Evaluation Tool PROKUS

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1 Necessity and occasions to evaluate the usability of software

Because of the increasing use of data processing in all fields in human life (e.g. work, education, leisure) the attention to a user-friendly software design is rising more and more. The quality and acceptance of an interactive human-computer system highly depends on the ergonomic design of the user interface. In the past, ergonomic aspects were often neglected when developing software and information systems. Thus, many users complain about the troubles in learning to use a software product or its insufficient functionality and complexity of interactions. Once the user gets dissatisfied with a software product, a dialogue system or an accessible interface, this dissatisfaction dominates the functionality and the productivity of the system.

ISO 9241-10 "Ergonomic requirements for office work with visual display terminals (VDTs), Part 10: Dialogue Principles" describes seven general ergonomic principles, which are independent from any specific dialogue technique. They are presented in this standard without any references to situations of application, use, environment, technology or user type (cf. Prümper1993). As commonly known the seven principles of ISO 9241-10 are:

- suitability for the task,
- self-descriptiveness,

- controllability,
- conformity with user expectations,
- error tolerance,
- suitability for individualisation, and
- suitability for learning.

These principles can be considered as general expectations for a user-friendly design of software or accessible interfaces. They should be obligate criteria for the user when assessing, evaluating, choosing and ordering one of the market's software products. Therefore the aim of the software developer must be the design and distribution of user-friendly software products and interfaces, which fulfil these standards.

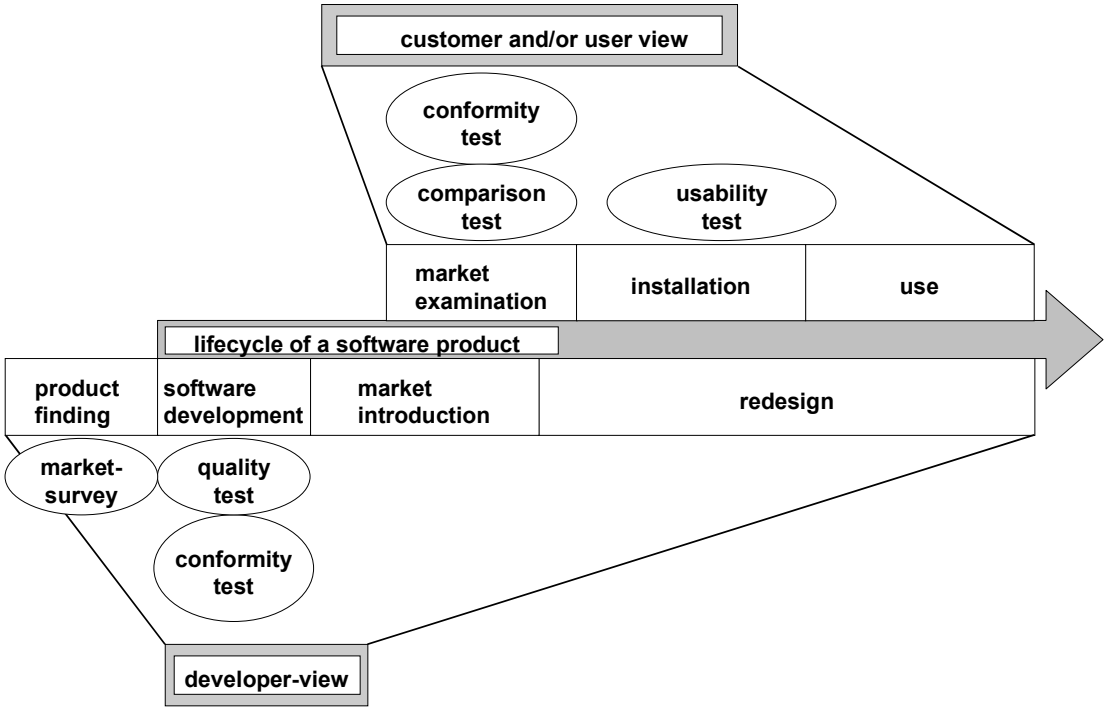

Figure 1: Occasions to evaluate software

The analysis and evaluation of software products or accessible interfaces, which should examine the adequate transfer of user-friendly standards to the design and development of products, can be realised at several occasions in the software lifecycle (figure 1). The first occasion is during the development process of the products by choosing an adequate human-computer interface (cf. Zülch & Englisch 1991, Englisch 1993). Quality tests assess mainly the functionality of a software product. Conformity tests compare the product with the requirements of the standards and evaluates the user-friendliness of interfaces and dialogues. Another occasion, performed by the customer or the future user, is helping to select a suitable product by examining existing products on the market and comparing these products (comparison test). In this product selection process, conformity tests are made to assess the adherence of user-friendly standards. When the software is already selected, several usability tests with additional goals and needs should be carried out in order to support the redesign phase.

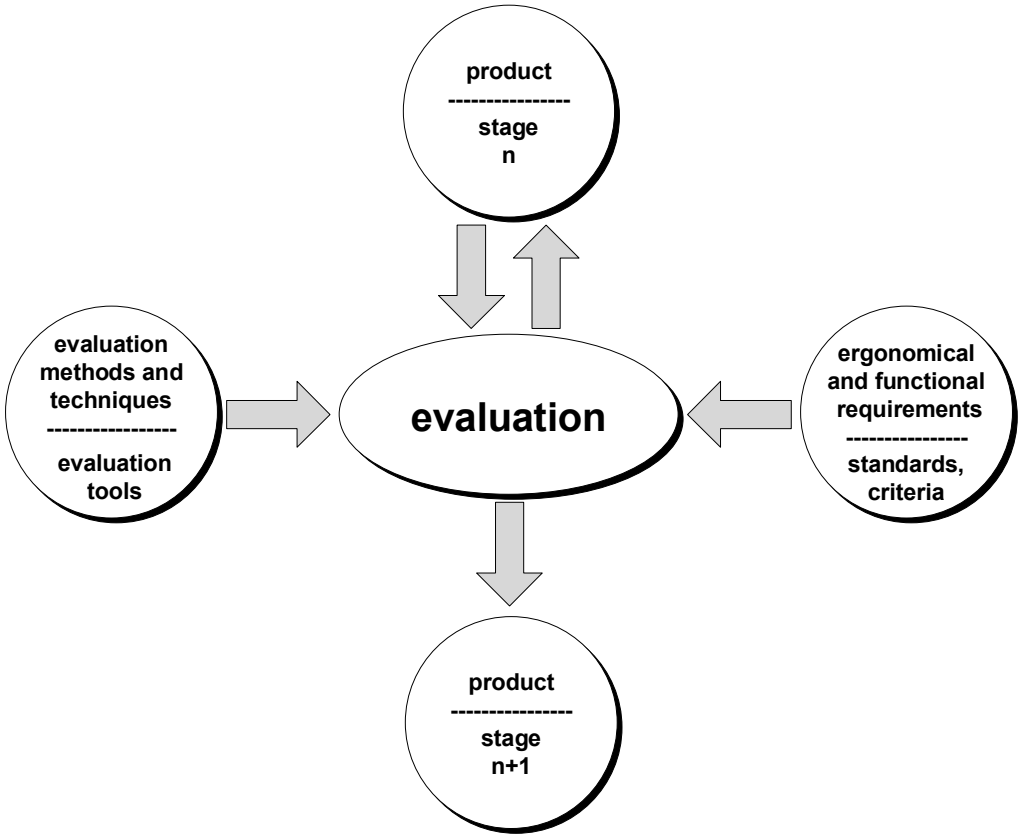

Figure 2: Basic model of evaluation (according to Zülch, Fischer & Stowasser 1998)

2 Evaluation process

The process of evaluating products, especially software products, can be exemplarily described according to the evaluation model as it is shown in figure 2. In a certain design stage, several evaluation tools, which base on different evaluation methods and techniques, can be deliberately used to assess and evaluate the product. The restrictive choice of the evaluation method and technique depends on the general requirements connected with the evaluation purpose. Such requirements can be derived from the demands of the user, the tasks operated with the software product and the state of technique. The requirements (e.g. ergonomical or functional) are to fulfil a standard, e.g. The guidelines, criteria, catalogues are used for the process to achieve this aim. In order to analyse whether a software product meets the requirements, the imposed criteria must be characterised through an evaluation tool.

3 Evaluation methods

The following chapter will describe several evaluation techniques and methods like interviews, guidelines and experimental evaluation.

3.1 Evaluating with interviews

To interview users is one of the commonly used evaluation techniques. We can fundamentally differ between two methods, the verbal and the written method of evalu-

ating the usability of human-computer interfaces. Verbal and written interviews are an inexpensive, familiar, and generally accepted method for usability tests and expert reviews (cf. Oppermann, Murchner, Reiterer & Koch 1992). Both methods aim at preparing a survey over the user's subjective opinion about specific characteristics of the software system like dialogue technique, syntax of inputs and design of interfaces, etc. Moreover, interviews aim to achieve personal information about the user, concerning background (age, education etc.), job responsibility, experience with computers and tasks to be fulfilled with it, feelings after using an human-computer interface, etc.

The method of online surveys can help to reduce the costs and efforts of printing, distributing, and collecting paper forms. Shneiderman (1998) reports on a survey of the World Wide Web utilisation which generated more than 13.000 respondents. It uses an ordinal scale ranging from 1 (very negative) to 9 (very positive) and takes missing data into account.

3.2 Evaluating with guidelines

With help of an evaluation guideline, one or more experts assess the user friendliness of a software-product or an accessible interface. Such guidelines are mainly orientated towards evaluating software-ergonomic aspects and not towards the functional usability (cf. Oppermann et al. 1992). The degree of detail is a distinguishing characteristic of the different guidelines which are available. The standard ISO 9241-10 can be regarded as a relative abstract guideline. In contrast to this, the guideline of the MITRE-Corporation (Smith, Mosier 1986) possesses one of the highest degrees of detail.

3.3 Experimental methods of evaluation

Experimental methods of evaluation range from simple observations of the user's actions to long-term experiments with detailed experimental design which take place as lab-examines or field-studies. While academics were developing controlled experiments to test hypotheses and support theories, practitioners developed experimental methods of evaluation in order to refine user interfaces rapidly (Shneiderman 1998). The following list enumerates some experimental methods of evaluation (cf. Grießer 1995 Zülch & Grießer 1995).

- Key stroke recording

  This method is used to notice interactions of the subjects. With this method it is possible to record exemplarily the time the user needs to perform a specific task, the mouse movements, the key-strokes, the interaction-rate (keystrokes per time), etc.

- Eye mark registration

  The eye mark registration is very useful to find out which spot on the interface the user is looking at, which type of information representation he prefers, and if he is working according to a specific strategy of problem solving. Both the visual field

and the fixation point can be overlaid, observed on a monitor and recorded on a video tape.

- Observation of the user

  By observing the user at work the expert can draw conclusions from the behaviour and reactions of the user. Generally, there are two observation forms: the covered and the uncovered observation. During a covered observation the observer and the subject are seated together in front of the interface. In case of an uncovered observation, test controllers and observers watch the test person in a usability laboratory through a half-silvered window or test persons are videotaped by performing the tasks.

4 Evaluation tool PROKUS

PROKUS (Programmsystem zur kommunikationsergonomischen Untersuchung rechnerunterstützter Verfahren), which has been developed at the ifab-Institute of Human and Industrial Engineering of the University of Karlsruhe, is a computer-system for the design of evaluation procedures and the carrying out of usability evaluations according to different evaluation situations. This tool can be classified as an evaluation method with guidelines and is applicable for systematic market examinations, conformity tests, quality tests and comparison tests.

4.1 The evaluation system

4.1.1 System elements of PROKUS

PROKUS is based on a catalogue with questions which are to be filled-in by an expert during the evaluation procedure. Central element of PROKUS is the exerciser database which consists of different series of investigations (figure 3).

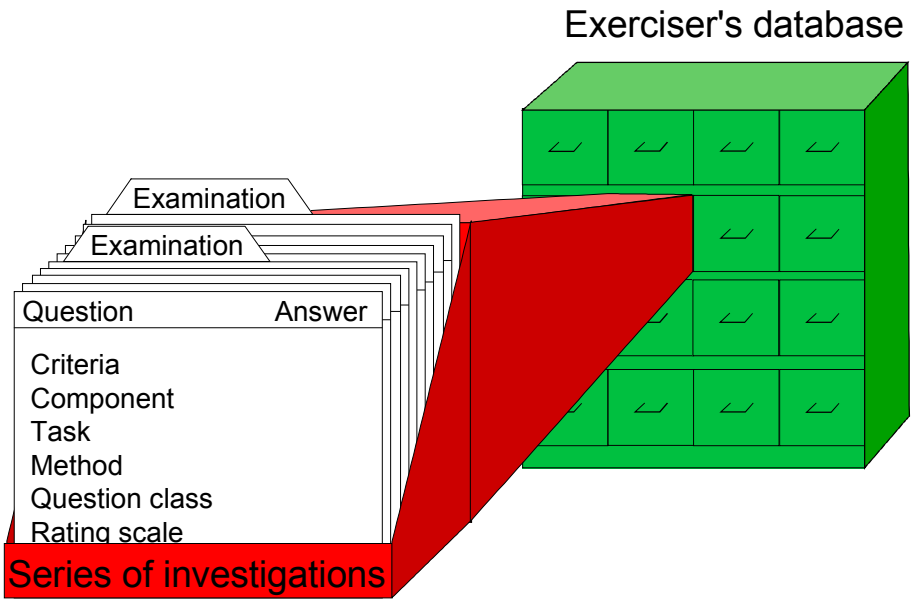

Figure 3: The evaluation tool PROKUS

Each series of investigations contains several examinations which consist of a series of questions. These questions could be based on each thinkable checklist, standard, guideline etc. For evaluation purpose the guideline, standard or the other foundation has to be transformed into a terminology of evaluation, e.g. into one or more questions with answer possibilities. Every question is described using the elements "criteria", "component", "task", "method", "question class" and "rating scale" (figure 4).

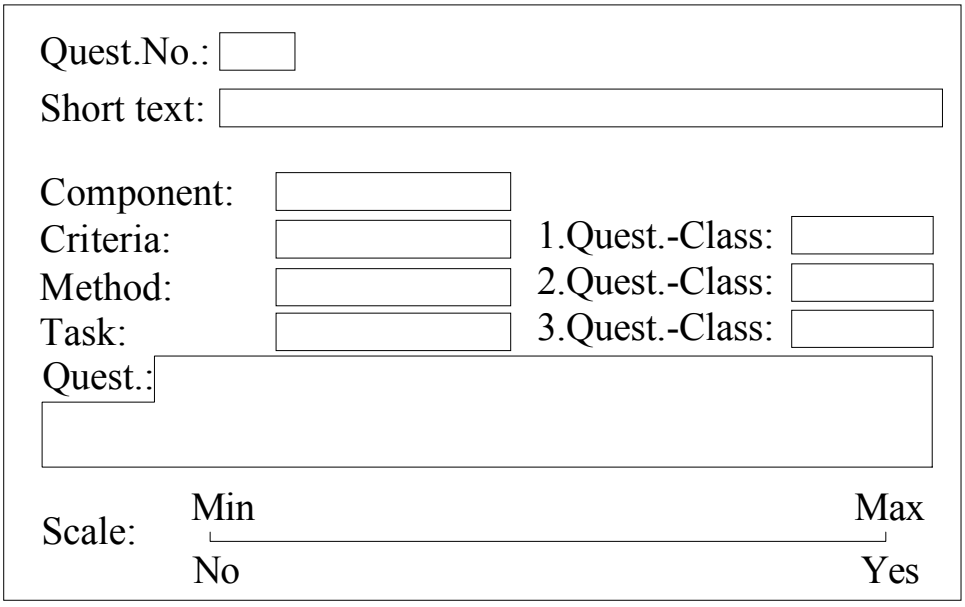

Figure 4: Input form for an evaluation question in PROKUS

The element "criteria" of the question represents the focused usability criteria. This criteria can be exemplarily derived from the seven general ergonomic principles (e.g. conformity with user expectations) which are described in ISO 9241-10. Of course, other criteria are conceivable. The element "component" represents essential characteristics of the software or the interface which is to be evaluated with the respective

question. One approach to arrange the components is the IFIP model for user interfaces developed by a working group of the German Informatics Community (GI)(IFIP stands for International Federation of Information Processing; cf. Dzida 1987). This hierarchically structured model has been constructed in order to develop guidelines for designing user interfaces in computer-aided design systems (CAD). As an example the components of human-computer systems include user, task and computer components with input/output, dialogue and tool components (cf. Zülch & Englisch 1991). The element "task" describes the function or purpose of the software-product or the interface according to the evaluated characteristic of the human-computer system (e.g. the button F7 is consequently used to save the data by the user). The element "method" represents the various test and evaluation methods, with which the expert can evaluate the software and measure the required data to answer the question. ISO 9241-14 recommends the application of the evaluation methods "measurement", "observation", "expert judgement", "documental evidence" and "user testing". Regarding the special occasion of the evaluation, the use of a special method may be required. Evaluation with these methods means, that the evaluator tests an existing system and measures the required data or he derives these data from existing documents. The element "question of class" gives the possibility to define a ranking of the questions (e.g. class of question "1" means a "very important" question). The element "rating scale" represents the answering field for the actual question. Depending from the type of questions, PROKUS offers answering fields for three types of scale, namely the nominal, ordinal and interval scale. The decomposition of evaluating procedures into elements and processes has been made for the purpose of developing a flexible tool for various requests of evaluation.

4.1.2 Evaluation process with PROKUS

With the assistance from such a catalogue of questions the expert is able to evaluate the human-computer system in an individually adjusted way which is documented for reproducing. The expert feeds the observed or measured data, which is the answer to the posed question, into the component "rating scale". The result can be recorded in three types of scales: nominal scale (e.g. online-learning possible "yes" or "no"), ordinal scale (e.g. design of the accessible interface "bad", "average", "good", "excellent") and interval scale (e.g. time to perform a task in seconds). This input data can be used for two different types of comparisons (cf. Zülch & Englisch 1991):

- Comparison with standards

  The measured data are compared directly with given requirements (e.g. guideline questions, expert recommended value, standards like ISO 9241). This comparison implies an existing standard of what is adequate for the system. Sometimes the standard is not sufficiently specified. In this case the evaluator compares with an imagination of an ideal situation. This is one of the reasons why evaluators should have practical experience with different systems.

- Comparison of different systems

  The measured data are compared with data of another human-computer system. In this case a comparison between two or more systems is performed. With this kind of comparison ergonomic-centred market study can be carried out.

4.1.3 Numerical evaluation result of PROKUS

The result of the systematic evaluation with PROKUS is a numerical degree of goal achievement and the assessment whether a human-computer system meets the given requirements (e.g. ISO 9241 or each other guidelines) or not. The case studies in chapter 5.2.3 explain the process to determine this level of compliance with the standard. The gained results are able to give the designer or developer concrete information in order to correct and improve the evaluated software. The storage of the answers of the evaluation questions and the numerical results of the evaluation secures a reproducible and duplicable documentation of the evaluation process.

The application of PROKUS can mainly be interesting for all those experts or users, who develop, collect or administrate a large amount of evaluation questions like software certification offices or research institutions. Another target group which can find help for evaluating and testing the developed products by using PROKUS are programmers in the field of software and interface design (e.g. software producers, web-designers).

4.2 Benefits in evaluating with PROKUS

Many procedures with different techniques and methods already exist for the evaluation of human-computer work systems and each evaluation refers an adaptation to a special situation. For that purpose PROKUS has been developed, to design evaluation procedures according to different evaluation environments, e.g. levels of detail or resources, and to carry out different processes in usability evaluation. The complexity of an evaluation procedure with help of PROKUS can reach from expert reviews, acceptance tests, usability tests in laboratories.

A continuative task in the concept of evaluation systems is to combine the evaluation system with a system that stores different design guidelines, standards or other aspects concerning the evaluating matter. The evaluation tool PROKUS supports evaluators, designers and users on one hand with practicable and testable guidelines for human-computer interface design and on the other hand with methodical procedures for collecting evaluation and applying questions. These questions can be selected and combined in such a way which is desired by the evaluator (of course a combination of questions of different standards, guidelines etc. is possible). For combining several questions PROKUS offers different sorting functions: e.g. choosing questions depending on just one evaluation method, questions for evaluating specific aspects (for instance only such questions which can be applied to testing the dialogue component).

4.3 Application of PROKUS for CAD or Web browser usability studies

With the help of PROKUS user interfaces of several CAD systems have already been evaluated within a series of usability studies. Based on ISO 9241-10 "Ergonomic requirements for office work with visual display terminals (VDTs), Part 10: Dialogue Principles" and ISO 9241-14 "Ergonomic requirements for office work with visual display terminals (VDTs), Part 14: Menu dialogues" PROKUS was used conformity tests. In this application approximately 50 questions were combined into an exami-

nation procedure. The results of these usability studies showed the difficulty of complying with all requirements of the standards (for further information refer to Zülch & Englisch 1991 and Zülch, Englisch & Grundel 1993).

Moreover, different web browsers (Microsoft Internet Explorer 5 and Netscape Navigator 4.5) have been actually tested within a extensive series of usability evaluations. At this occasion a conformance testing with ISO 9241 (Parts 14, 16, 17) was used. The evaluation was made with altogether 288 questions (63 criteria, 24 scales, 21 methods, 13 tasks). Detailed results can be shown in the immediate future.

The following chapter describes another recently completed case study on evaluating human-computer interfaces with PROKUS. In this study a computer-aided simulation system was tested to which extent it fulfils the required standards of ISO 9241-10.

5 Usability evaluation of a simulation system

Two versions of a computer-aided simulation system (an earlier DOS-version and the current version for Windows95) has been evaluated with support of the evaluation tool PROKUS. On the one hand the evaluation should determine whether each software-tool meets individually the requirements concerning usability, in this case the standard ISO 9241-10, and on the other hand the investigation should compare the versions with each other in order to treasure the progress concerning user-friendliness.

5.1 General conditions of the evaluation study

5.1.1 The simulation system FEMOS

The simulation system FEMOS (Fertigungs- und Montage-Simulator; cf. Zülch & Grobel 1992) which has been investigated in this evaluation study, is especially designed for the re-organisation or production systems. It offers a wide range of modelling features to demonstrate and assess the dynamic effects when changing the departmental and workflow organisation. Furthermore it supports the personnel capacity planning in production. Thereby, the behaviour of the production system can be analysed in a simulation model with help of logistic keydata (e.g. the lead time of orders, the utilisation of resources, etc.). A screenshot of the online-monitoring of order processing and waiting queues with FEMOS for Windows95 is shown in figure 5.

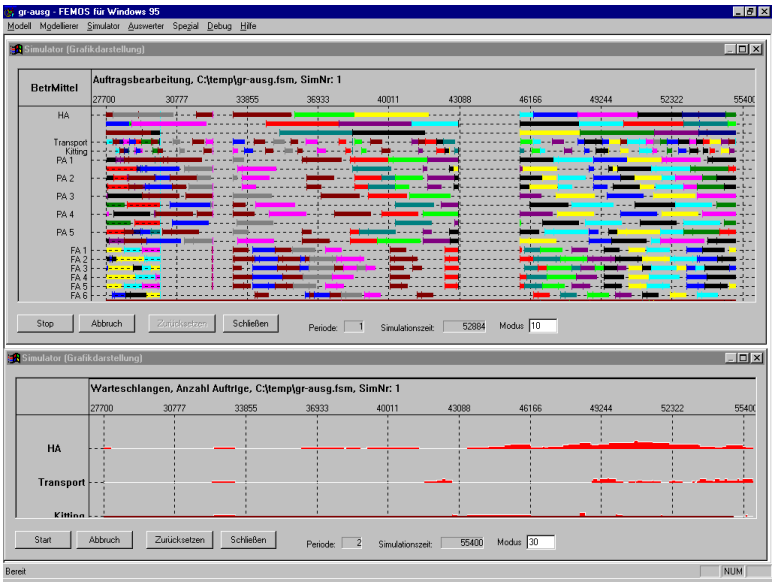

Figure 5: Monitoring-screenshot of the software FEMOS for Windows95

5.1.2 The user group

FEMOS is designed for the use of consultants or production planners without any programming knowledge. But, for the use of such a simulation tool a profound knowledge in the field of planning, modelling and simulation is necessary (Grobel 1992). The simulation tool FEMOS is mainly used by production planning and simulation experts. Therefore, a homogenous user group with highly qualified planners having knowledge in simulation is assumed for the evaluation study. Moreover, experience in human-computer-interactions and mainly in the use of PCs is presupposed.

5.1.3 The evaluation process

Two versions of FEMOS are evaluated with the evaluation tool PROKUS. The performed conformity tests compare the two versions with the of the ISO 9241-10 and evaluate the user-friendliness of interfaces and dialogues. Both tests are independent from each other: they are not carried out simultaneously at the same time. For each conformity test a series of investigations has to be defined (figure 6). This series of investigations contains several examinations for the seven general ergonomic principles which are described in ISO 9241-10. These examinations are again arranged by a series of questions which are stored in the exerciser's database of PROKUS (cf. Figure 3). Both interfaces were examined using 57 questions of the database.

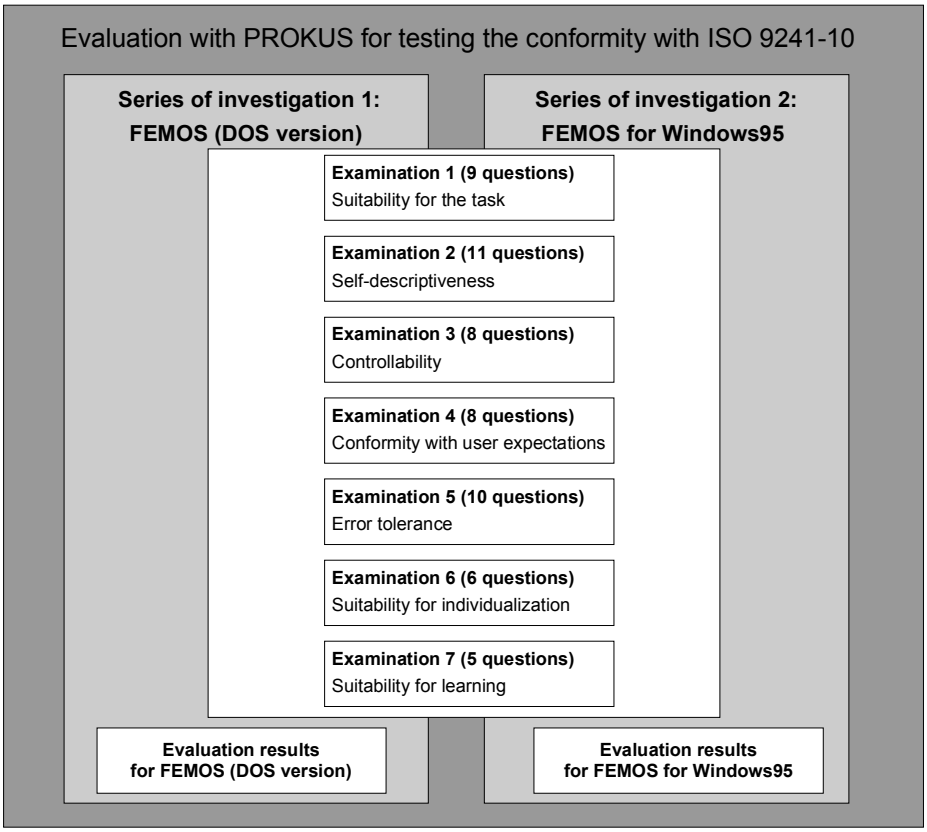

Figure 6: Structure of the PROKUS evaluation study for FEMOS

5.1.4 Choosing evaluation questions

For the purpose of evaluating the two versions of FEMOS the evaluators selected 57 questions which shall prove the conformance with a standard (in this investigation ISO 9241-10). Every question has to be transformed into a terminology of evaluation, e.g. into one or more questions with answer possibilities and is described using the elements "criteria", "component", "task", "method", "question class" and "rating scale". The criteria used in the investigation proceed from the seven dialogue principles "suitability for the task", "self-descriptiveness", "controllability", "conformity with user expectations", "error tolerance", "suitability for individualisation" and "suitability for learning". The selected questions has been fitted to a typical utilization environment which represents typical simulation tasks. Thus, the evaluation process can be compared with a representative scenario in using the simulation software.

5.1.5 Applicable evaluation questions

ISO 9241 mainly consists of recommendations which have to be fulfilled if a certain condition is met. Therefore in this case study, not all evaluation questions of the exerciser's database are applicable and can be answered. This fact is shown in figure 7, whereby question 1.1 and question 1.2 are assumed to meet the condition in this evaluation. Consequently, it is unavoidable to check the conditions for each recommendation before answering an evaluation question. For example, the recommendations for working with a window system could only be answered if the software-tool really provides one or more windows.

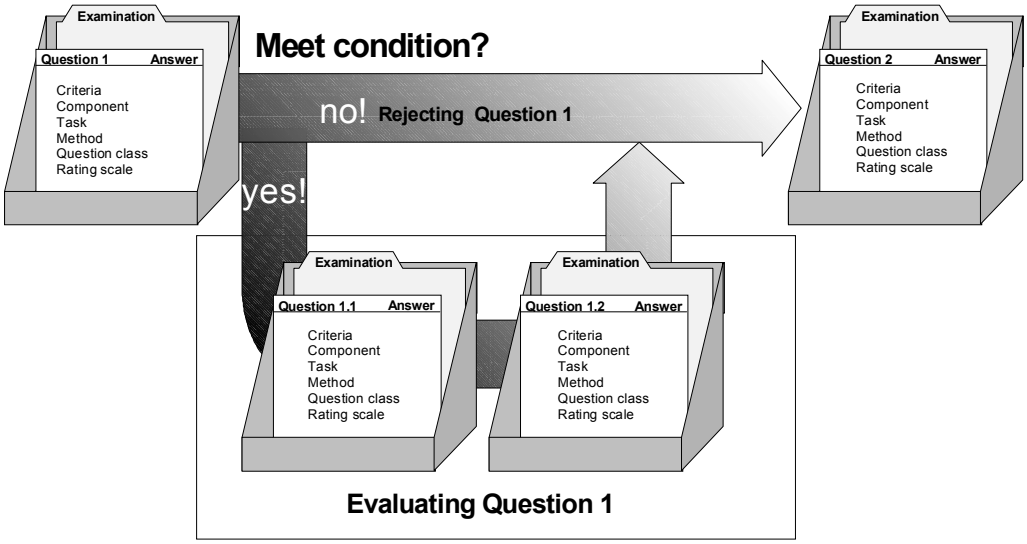

Figure 7: Applicability of evaluation questions with PROKUS

ISO 9241 recommends the application of the investigation methods "measurement", "observation", "expert judgement", "documental evidence" and "user testing" in order to check to which extent the evaluation questions are fulfilled. Figure 8 shows a screenshot of PROKUS with an evaluation question for testing the conformity with ISO 9241-10.

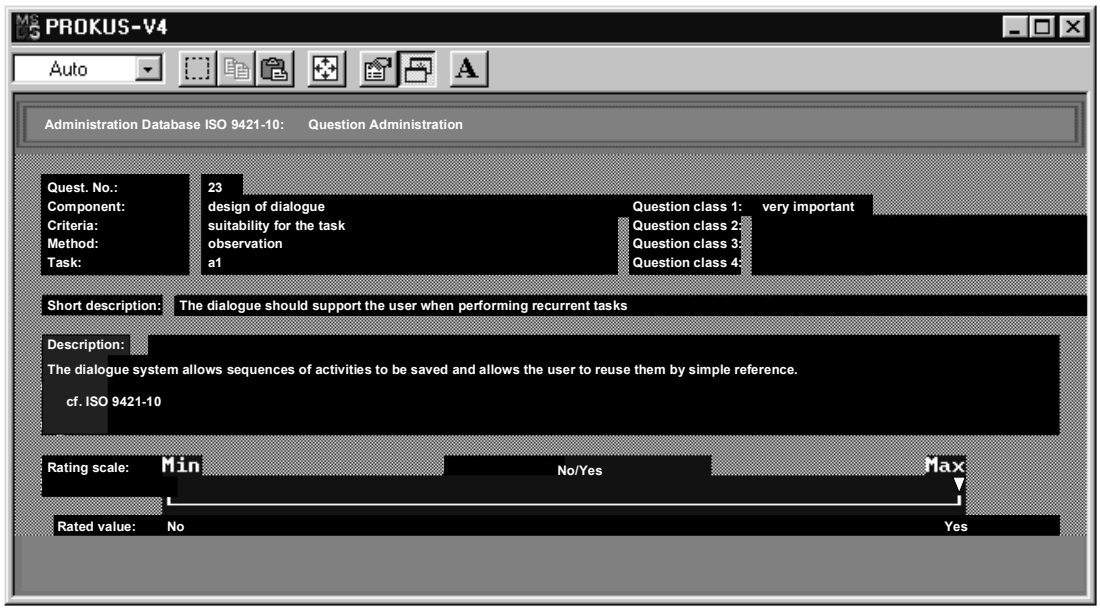

Figure 8: Example of an evaluation question for conformity testing

In the following investigation of the computer-aided simulation tool FEMOS the assessment of the evaluation questions runs through a two-step answering process:

Step 1: The evaluator checks whether the question is an applicable one or not. A non-applicable question can not be answered and has no impact to the evaluation.

Step 2: The evaluator evaluates the applicable questions. In conformity tests concerning ISO 9241-10 the questions are rated by a three-choice system with

- "Fulfilled": The software tool completely corresponds with the specific requirements of the standard and fulfils the evaluation question.
- "Partly fulfilled": The software tool mainly corresponds with the standard, however it differs in less relevant aspects from the requirements and thus fulfils only partly the specific evaluation question.
- "Not fulfilled": The software tool does essentially not correspond with the standard and, so, does not fulfil the specific evaluation question.

5.2 Results of the evaluation

5.2.1 Evaluation of the DOS-version of FEMOS

The results of the should be-as is comparisons are shown in figure 9. When evaluating the DOS-version of FEMOS with PROKUS only 2 of all 57 evaluation questions are not applicable (that is equivalent to 3.5 %).

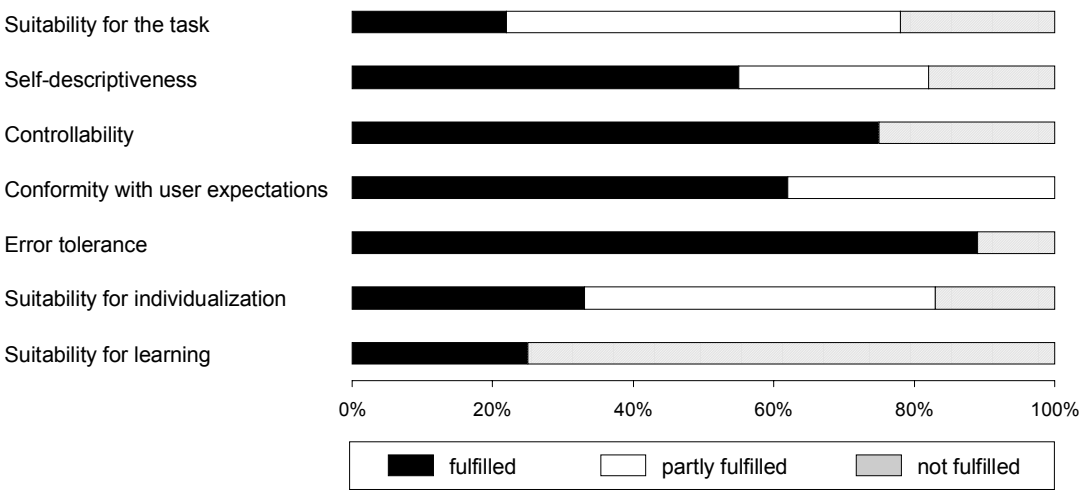

Figure 9: Evaluation concerning dialogue principles (ISO 9241-10) for the DOS-version of FEMOS

The interface has a low level of non-performance in "Suitability for learning" caused by the default of any help-information. Learning-by-doing is not supported. No interactive online tutorials are available and, therefore, the simulation tool does not assist any learning strategy (learning-by-doing, learning-by-example, etc.). The usability principle "suitability for the task" only reaches a level of approximately 22 % on complete fulfilment. Worth mentioning in this context is that FEMOS does not allow sequences of activities to be saved and to reuse them by simple reference (e.g. function key). The most fulfilled questions can be detected for the principles "controllability", "conformity with user expectations" and "error tolerance".

5.2.2 Evaluation of FEMOS for Windows95

Figure 10 summarises the results of evaluating the simulation tool FEMOS for Windows95. 54 applicable questions have been considered in this series of investigation,

so that 3 questions (or 5 %) are non-applicable ones. The dialogue principle "suitability for learning" is general not fulfilled by FEMOS for Windows95. So, it is very difficult for less advanced users to get familiar with the simulation tool during the learning phase. Moreover, FEMOS for Windows95 does not provide a complete help-system which results in a reduced level of fulfilment concerning the dialogue principle "self-descriptiveness". The dialogue recommendations "conformity with user expectations" and "controllability" as well as "error tolerance" are mainly satisfied by this simulation tool.

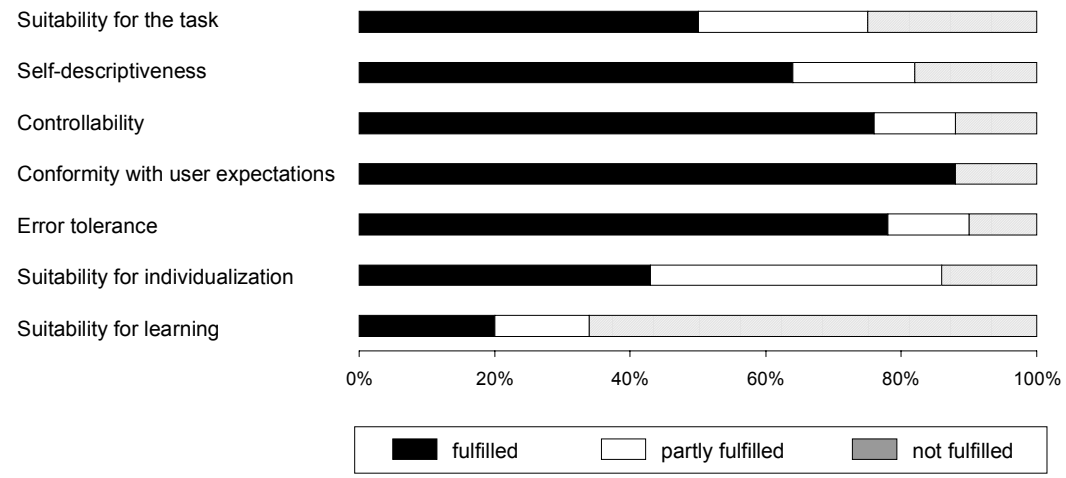

Figure 10: Evaluation concerning dialogue principles (ISO 9241-10) for FEMOS for Windows95

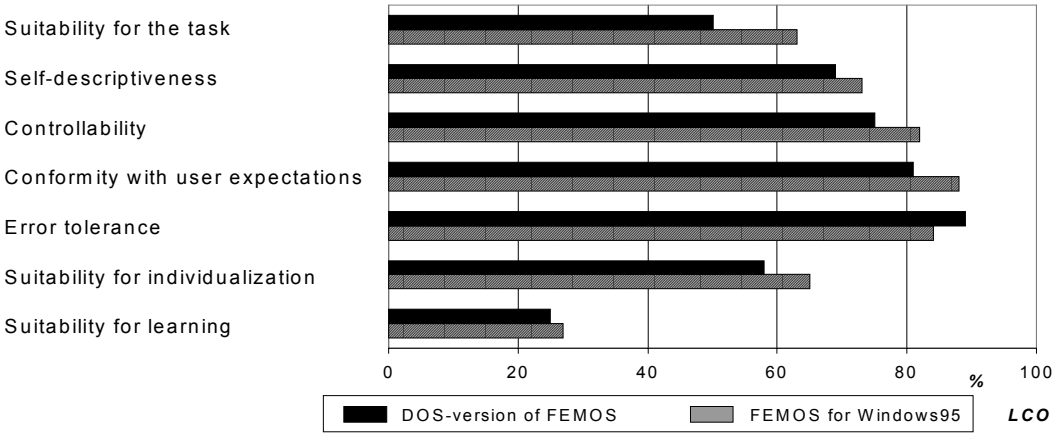

Figure 11: Level of compliance concerning dialogue principles of ISO 9241-10

5.2.3 Comparison of the two versions

The interpretation system of PROKUS includes various possibilities to aggregate and interpret data of the evaluation. One possible result of the conformity test is the level of compliance (LCO) with the standard, which is the number of fulfilled questions divided by the number of tested questions in percent. Considering the simulation tool versions the results for the dialogue principles are shown in figure 11.

As a result of the evaluating study, the overall level of compliance for the DOS-version of FEMOS is 64 %. Compared with this, FEMOS for Windows95 measures 69 %. But none of its interfaces has a complete conformance with the standard ISO 9241-10. Although the transition from DOS-version to FEMOS for Windows95 increases the user-friendliness for most of the dialogue principles (except for "error tolerance") the requirements are still incompletely met by FEMOS for Windows95. The results of the conformity test shows that both interfaces need corrections to meet the standard. Additionally performed questionnaires and experiments with users in laboratory experiments confirm these results.

These results should be the basis for an improvement process of the simulation tool FEMOS. Exemplarily, it is rarely possible to adapt individually the settings of FEMOS, which leads to a reduced level of compliance of the principle "suitability for individualisation". Especially this is an important part to reach a user friendliness software tool, which fulfils the satisfaction of several users.

6 Further steps for improvements

The article emphasises that the adequate methods and techniques for evaluating interfaces and human-computer dialogues are needed to assess and meet the ergonomical and functional requirements of software products. However, usability evaluation is a rather complicated and complex process. Furthermore, the evaluation of accessible interfaces (e.g. web pages) becomes more and more important. New standards for multimedia interfaces, web pages or further advanced information and data technologies (virtual reality etc.) have to be developed and have to been transferred into the design of these modern human-computer systems. This will certainly raise new questions for fundamental research and practical evaluation procedures. A continuative task in the concept of evaluation systems is to combine the evaluation system with a system that sores design guidelines. Goal of this work is to support designers with practicable and testable guidelines for human-computer interface design.

The paper introduces the computer-aided evaluation tool PROKUS. PROKUS can be used for designing and carrying out systematic usability evaluations for any software and can be adapted to different occasions of evaluation. The result is a numerical degree of achievement, the level of compliance, which shows the quality of the evaluated software. An insight into the work with PROKUS is exemplarily given by the case study of evaluating two versions of a simulation tool. Moreover, PROKUS can be adapted to a variety of scenarios of human-computer interfaces. Additional evaluation questions (e.g. for evaluating modern multimedia interfaces, virtual reality tools) can be easily supplemented to the exerciser database. A systematic combination of these questions may serve as a basis for further evaluations of future interfaces.

7. References

Dzida, W. (1987). On Tools and Interfaces. In: Frese, M.; Ulich, E. & Dzida, W. (Edts.). *Psychological Issues of Human Computer Interfaces in the Work Place*, 339-355. Amsterdam et al.: North Holland.

Englisch , J. (1993). *Ergonomie von Softwareprodukten.* Mannheim et al.: BI-Wissenschaftsverlag.

Grießer, K. (1995). *Einsatz der Blickregistrierung bei der Analyse rechnerunterstützter Steuerungsaufgaben.* ifab-Forschungsberichte Nr. 10, Uni Karlsruhe: Institut für Arbeitswissenschaft und Betriebsorganisation.

Grobel, T. (1992). *Simulation der Organisation rechnerintegrierter Produktionssysteme*. ifab-Forschungsberichte Nr. 3, Uni Karlsruhe: Institut für Arbeitswissenschaft und Betriebsorganisation.

ISO 9241-10 (1993). *Dialogue Principles*. Draft International Standard.

ISO 9241-14 (1994). *Menu dialogues*. Draft International Standard.

Oppermann, R.; Murchner, B.; Reiterer, H. & Koch, M. (1992). *Software-ergonomische Evaluation*. Berlin, New York: Walter de Gruyter.

Prümper, J. (1993). Software-Evaluation based upon ISO 9241 Part 10. In: Grechenig, T. & Tscheligi, M. (Edts.). *Human Computer Interaction*, 255-268. Berlin et al.: Springer.

Shneiderman, B. (1998). *Designing the User Interface*. Reading MA: Addison-Wesley.

Smith, S. J. & Mosier, J.(1986). *Guidelines for Designing User Interface Software*. Bedford MA: MITRE-Corporation.

Zülch, G. & Englisch, J. (1991). Procedures to evaluate the usability of software products. In: Bullinger, H.-J. (Edt.). *Design and Use of Interactive Systems and Work with Terminals*, 614-624. Amsterdam et al.: Elsevier.

Zülch, G.; Englisch, J. & Grundel, C. (1993). Beurteilung der Benutzungsfreundlichkeit von Programmsystemen. *Fortschrittliche Betriebsführung und Industrial Engineering*, 5, 267-272.

Zülch, G.; Fischer, A. E. & Stowasser, S. (1998). Evaluation von Software. *Ergo-Med*, 4, 194-198.

Zülch, G. & Grießer, K. (1995). Problem solving strategies in shop-floor control systems. In: Grieco, A. et al. (Edts.). *Work with display units '94*, 253-258. Amsterdam et al.: Elsevier.

Zülch, G. & Grobel, T. (1992). Simulating the Departmental Organization for Production to Order. In: Hirsch, B.E.& Thoben, K.-D. (Edts.). *'One-of-a-Kind' Production: New Approaches*, 177-193. Amsterdam u.a.: North-Holland.