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Ergonomics of human-system interaction — Usability methods supporting human-centred design

Ergonomie de l'interaction homme-système — Méthodes d'utilisabilité pour la conception centrée sur l'opérateur humain

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Foreword

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

Attention is drawn to the possibility that some of the elements of this Technical Report may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TR 16982 was prepared by Technical Committee ISO/TC 159, *Ergonomics*, Subcommittee SC 4, *Ergonomics of human-system interaction*.

Introduction

There is a growing emphasis on “human-centred design” as an essential part of the development of computer based systems. ISO 9241-11 and ISO 13407 provide “guidance on usability” and “on human-centred design processes for interactive systems”. ISO 13407 provides general guidance and four main conditions to make a product (hardware and software) “human-centred” but does not address specific methods.

The purpose of this Technical Report is to help project managers make informed decisions about the choice of usability methods to support human-centred design as described in ISO 13407 (with support from human-factors specialists, as appropriate). It is not its aim to turn the project manager into a human-factors specialist.

This technical Report provides an overview of existing usability methods which can be used on their own or in combination to support design and evaluation. Each method is described with its advantages, disadvantages and other factors relevant to its selection and use. These include the implications of the project's stage in the life cycle for the choice of method.

Since the appropriateness of individual methods is dependent upon the design activities being undertaken, it is necessary to relate them to the design process. ISO/IEC 12207 is used to provide the basic framework against which the suitability of the methods is assessed.

Annex A provides a template for practitioners, annex B gives real life examples when filling in this template and annex C provides detailed additional methods and techniques.

Ergonomics of human-system interaction — Usability methods supporting human-centred design

1 Scope

This Technical Report provides information on human-centred usability methods which can be used for design and evaluation. It details the advantages, disadvantages and other factors relevant to using each usability method.

It explains the implications of the stage of the life cycle and the individual project characteristics for the selection of usability methods and provides examples of usability methods in context.

The main users of this Technical Report will be project managers. This Technical Report therefore addresses technical human-factors and ergonomics issues only to the extent necessary to allow managers to understand their relevance and importance in the design process as a whole.

Such issues are dealt with more fully in ISO 9241 which is complementary to this Technical Report and is aimed at system developers, specifiers and purchasers of systems. Nonetheless, all parties involved in human-centred system development, including the end users of systems, should find the guidance in this Technical Report relevant.

The guidance in this Technical Report can be tailored for specific design situations by using the lists of issues characterizing the context of use of the product to be delivered. Selection of appropriate usability methods should also take account of the relevant life-cycle process.

This Technical Report is restricted to methods that are widely used by usability specialists and project managers.

It does not specify the details of how to implement or carry out the usability methods described.

NOTE Most methods require the involvement of human-factors specialists. It may be inappropriate for them to be used by individuals without adequate skills and knowledge.

2 References

ISO 9241 (all parts), *Ergonomic requirements for office work with visual display terminals (VDTs)*

ISO/IEC 12207, *Information technology — Software life cycle processes*

ISO 13407:1999, *Human-centred design processes for interactive systems*

ISO/IEC 14598 (all parts), *Software engineering — Product evaluation*

3 Terms and definitions

For the purposes of this Technical Report, the following terms and definitions apply.

3.1
prototype
representation of all or part of a product or system that, although limited in some way, can be used for evaluation

[ISO 13407:1999]

3.2
user
individual interacting with the system

[ISO 9241-10:1996]

3.3
usability
extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use

[ISO 9241-11: 1998]

3.4
usability method
method supporting human-centred design used for the purpose of increasing the usability of a product or a system

4 Adequate deployment of usability methods

4.1 General

Usability methods help to ensure that systems can be developed to meet the usability goals of a human-centred design process, described in more detail in ISO 13407.

The benefits of a human-centred approach include increased satisfaction and productivity, enhanced quality of work, reductions in support and training costs and improved user health and well-being. The usability methods described in this Technical Report support these goals.

Basic knowledge about the usability methods, including an understanding of their key differences and the basic principles of their application, is needed to be able to make an appropriate choice of usability methods.

Usability methods provide a means to increase the chances that systems deployed or to be deployed will achieve these objectives.

4.2 Basic principles issued from ISO 13407

ISO 13407 identifies four basic principles:

a) appropriate allocation of function between user and system, based on an appreciation of human capabilities and demands of the task;

b) active involvement of users in order to enhance the new system and its acceptance;

c) iteration of design systems to entail the feedback of users following their use of early design systems;

d) multi-disciplinary design teams to allow a collaborative process which benefits from the active involvement of various parties, each of whom have insights and expertise to share.

The application of these principles leads to the identification of four key human-centred design activities which should be undertaken to incorporate usability requirements into the development process and which are carried out in an iterative fashion and repeated until the particular usability objectives have been attained. The user-centred design activities are as follows.

1) Understand and specify the context of use. This information can be gathered via a variety of methods, this Technical Report intends to help make an adequate choice from these methods.

2) Specify the user and organizational requirements.

3) Produce designs and prototypes.

4) Carry out user-based assessment.

4.3 Methods and their use

4.3.1 Methods and methodologies

The usability methods which are described in this Technical Report stand-alone i.e. they can be selected and used for a variety of purposes (e.g., for user needs analysis, for establishing requirements, for design and specification, for evaluation) and many of them can be used concurrently or sequentially within a larger framework of human-centred design methodologies. Such methodologies are not covered in this Technical Report. Methodologies can result from the ad hoc selection of several methods within the same design process or from methodologies commonly used or described in the human-factors literature. Examples of such methodologies are: activity and task analyses methodologies that can group interviews, user observation, questionnaires, and even experiments; walkthrough and parallel-design methodologies that can group various evaluation methods, various expert and non-expert assessments, as well as creativity aspects together. References to published methodologies are provided in the bibliography.

4.3.2 Design and evaluation perspectives

The usability methods described in this clause apply in general to both design and evaluation. Specific choice (or selection) of these methods, depending on their design stages, is described in clause 6.

The main difference between design and evaluation in terms of their use of usability methods is a difference in focus. The difference is as follows.

— The focus of design is to determine users' knowledge, capabilities and limitations relative to the tasks for which the product or system is being designed. Of particular interest are the ways in which system and product designers can understand better users' tasks and task vocabulary, users' physical capabilities, etc. This information is used to guide the design of the system or product to maximize its usability. Often, this focus leads to the discovery of unanticipated ways in which users view the operation or use of a product or system. This focus may involve the comparison of competing designs to determine which is more usable.

— The focus of evaluation is to assess a design on a particular dimension (e.g., interface features, recommendations, standards) or against a model (e.g. user model, expected task completion time, expected use pattern), with some kind of measurement and data-gathering tools (e.g. questionnaires, errors-logging, time-stamp), according to users' performance or preferences.

With this difference in focus in mind, various usability methods are presented that can be used either to diagnose problems or to facilitate design and redesign.

— In the first case, the methods, often labelled data-gathering techniques, are usually described within the phase of the project which involves the description and modelling of job, tasks and users at various degrees of precision, though they may also be used for evaluation.

— In the second case, the methods are often labelled evaluation methods, though they are also used for design.

The focus of these methods may be the actual system being evaluated, or a prototype, or even an existing situation that does not incorporate a computer system yet (for example, when a completely new application is being designed).

To sum up, all of the usability methods described in this clause are human-centred ways of gaining a better understanding of the situation and context. That will allow for either assessment of whether the human-centred goals are met (evaluation) or will provide requirements, limitations or suggestions for designing systems (models, scenarios, prototypes or full systems) that will eventually be evaluated in an iterative process.

4.3.3 Use of several methods

Individual usability methods are described in clause 5. However, in practice, several usability methods may be used together, e.g. interviews and observations. Also, different methods may be used to address different issues during the life of a project.

It is useful for these reasons to avoid limiting oneself to one preselected method. The more methods used to achieve the usability objectives, the better the results will be.

Several methods can be used jointly (e.g. inspection and user testing, creativity methods and formal methods, critical incidents and expert evaluation, questionnaire and interviews). Using several methods may, in this way, increase the coverage of the results.

Examples of situations using a mix of usability methods are presented in annex B.

4.4 Direct involvement of users as a key factor

The active involvement of users is one of the key principles underlying the human-centred design process. Many of the usability methods described here provide a means of gaining that active involvement. In addition, there are also many usability methods that do not require users to be directly involved since they rely on other sources of information about user issues. They should be used to complement the active involvement of users.

4.5 Available methods

The methods that are presented in this Technical Report are those that are most frequently used. Table 1 lists each method. Variants of these methods are used under other names. A list of known variants (in books or on web sites) is provided in the bibliography.

Methods are divided into two broad categories (see Table 1, Column 2):

— methods that imply the direct involvement of users (Y = yes);

— methods that imply the indirect involvement of users (N = no) which are used either when it is not possible to gather usage data due to non-availability of the users or where they provide complementary data and information.

Table 1 — Brief description of the referenced methods

Name of the method	Direct involvement of users	Short description of methods
Observation of users	Y	Collection in a precise and systematic way of information about the behaviour and the performance of users, in the context of specific tasks during user activity.
Performance-related measurements	Y	Collection of quantifiable performance measurements in order to understand the impacts of usability issues
Critical incidents analysis	Y	Systematic collection of specific events (positive or negative).
Questionnaires	Y	Indirect evaluation methods which gather users' opinions about the user interface in predefined questionnaires.
Interviews	Y	Similar to questionnaires with greater flexibility and involving face-to-face interaction with the interviewee
Thinking aloud	Y	Involves having users continuously verbalize their ideas, beliefs, expectations, doubts, discoveries, etc. during their use of the system under test.
Collaborative design and evaluation	Y	Methods which allow different types of participants (users, product developers and human-factors specialists, etc) to collaborate in the evaluation or design of systems.
Creativity methods	Y/N	Methods which involve the elicitation of new products and systems features, usually extracted from group interactions. In the context of human-centred approaches, members of such groups are often users.
Document-based methods	N	Examination of existing documents by the usability specialist to form a professional judgement of the system
Model-based approaches	N	Use of models which are abstract representations of the evaluated product to allow the prediction of the users' performance.
Expert evaluation	N	Evaluation based upon the knowledge, expertise and practical experience in ergonomics of the usability specialist.
Automated evaluation	N	Algorithms focused on usability criteria or using ergonomic knowledge-based systems which diagnose the deficiencies of product compared to predefined rules.

4.6 Choice of usability method(s) (UM)

4.6.1 Factors affecting the choice of methods

The factors affecting the choice of methods are

a) the life-cycle steps,

b) the characteristics of the users,

c) the characteristics of the task to be performed,

d) the product or system itself,

e) the constraints which affect the project, and

f) the degree of expertise in ergonomics available in the development or evaluation team.

4.6.2 Suitability of methods

The issues identified are evaluated on a scale of five levels as follows:

— recommended (++);

— appropriate (+);

— neutral (when the cell is empty);

— not recommended (–);

— not applicable (NA).

There may be a number of candidate usability methods which could be used to gather the information required. Some of the methods may be eliminated because they cannot be used in a particular context. For example, if there are no current users, it will not be possible to interview them and this would lead to a rating of (NA), i.e. the method is not applicable. On the other hand, if there are current users but they are not fully representative of the characteristics of future users, interviews may be appropriate (+) but an analytical method may also receive a recommendation. The decision about whether or not to use a combination of methods, and the level of detail needed should be taken, bearing in mind the risk that poor design will lead to errors or a lack of satisfaction.

These ratings are based on typical situations and should be reviewed in the context of a specific project.

5 Usability methods

5.1 Methods that imply the direct involvement of users

5.1.1 General

These methods can be used when it is possible to gather data directly from users, or when there is access to users.

5.1.2 Observation of users

This method consists of the precise and systematic collection of information about the behaviour and the performance of users, in the context of specific tasks during the user's activity which may be carried out either in real-life situations or laboratories. Such observation is structured and based on predefined classifications of users' behaviour.

Much observation is based on taking detailed notes on what the users do and then analysing the data later.

The advantages and disadvantages of this method are as follows.

Advantages

— Method can be performed in “real world” settings;

— real activity is reported.

Disadvantages/constraints

— It is time consuming to analyse the data;

— needs expertise to accurately interpret data;

— no direct insight into mental processes.

The following are examples of the types of quantitative and qualitative information which can be logged:

— different actions involved in achieving task goals: interaction with the computer, including physical behaviour, interaction with other tools or other persons;

— numbers of attempts to complete a task;

— reasons for success or failure.

5.1.3 Performance-related measurements

Performance-related measurements are also called task-related measurements.

The commonly used quantifiable performance measurements related to effectiveness and efficiency include the following:

— time spent to complete a task;

— number of tasks which can be completed within a predefined duration;

— number of errors;

— time spent recovering from errors;

— time spent locating and interpreting information in the user's guide;

— number of commands utilized;

— number of systems features which can be recalled;

— frequency of use of support materials (documentation, help system, etc.);

— number of times that the user task was abandoned;

— number of digressions;

— amount of idle time (it is important to distinguish between system-induced delays, thinking time and delays caused by external factors);

— number of total key strokes.

Performance-related measurements can often be performed on the whole system or a part of it.

The advantages and disadvantages of this method are as follows.

Advantages

— Collects quantifiable data;

— results are easy to compare.

Disadvantages/constraints

— Does not necessarily uncover the cause of problems;

— requires some kind of working version of system or product.

For additional methods, see Annex C.

5.1.4 Critical-incident analysis

Critical-incident analysis consists of the systematic collection of events which stand out against the background of user performance. The incidents are described in the form of short reports which provide an account of the facts surrounding the incident. The data can be collected from interviews with the user and from objective observations of the interaction. The incidents are then grouped and categorized.

Whereas performance-related measurements have current tasks and existing situations as the focus of interest, critical-incident techniques enable the examination of significant events, positive or negative, which may have occurred in the past or over a period of time.

The advantages and disadvantages of this method are as follows.

Advantages

— Collects causes of problems;

— focuses on events where demands on users are high;

— real activity is reported.

Disadvantage/constraints

— May require a long elapsed time to complete;

— insufficient events to report can effect the validity of the analysis.

5.1.5 Questionnaires

There may be several occasions during development when it will be useful to gather information from users using questionnaire items. The questionnaire items can be either open-ended statements or checklist/closed questionnaire items and scales: the advantage of the former is that they allow people to give elaborate answers but there is always a danger of collecting only cryptic statements which are difficult to interpret. For this reason, the closed questionnaire item format is often preferred.

Standardized questionnaires can also be used for systematic comparisons, for example between design features or between competing designs.

The type of data being collected can include users' quantifications, suggestions, opinions and ratings of the systems, features, user help, preferences, ease-of-use, etc. Qualitative methods are generally indirect in that they do not study the user interaction but only users' opinions about the user interface.

There is also a need for including consistency checks in questionnaires, for example using different question formats referring to the same item. For this reason, closed questions are often preferred.

The advantages and disadvantages of this method are as follows.

Advantages

— Uncovers subjective preferences;

— easy to manage;

— quick to conduct.

Disadvantages/constraints

— Self-evaluation can be unreliable as a measure of performance;

— questionnaire items open to bias both in the questions and the answers.

5.1.6 Interviews

Interviews are similar to questionnaires but with greater flexibility since there is face-to-face interaction with the interviewee.

There are many different forms of interview from highly structured to very open-ended. Interviewing an user on an individual basis requires much more staff time than administering a questionnaire.

Interviews have the advantage, however, of being more flexible since the interviewer can explain difficult questions more deeply or reformulate a question if it is unclear to the user. Interviewers can also follow up answers that require further elaboration or that lead to new insights which had not been anticipated in the design of the interview.

The advantages and disadvantages of this method are as follows.

Advantages

— Collects quick overview of users' opinion;

— flexible, allows probing per users' responses.

Disadvantages/constraints

— Detailed analysis is time consuming ;

— it is open to biases (both in the questions and the answers);

— needs expertise to accurately interpret data.

5.1.7 Thinking aloud

Thinking aloud involves having users continuously verbalize their ideas, beliefs, expectations, doubts, discoveries, etc. during their activity when using the system. Thinking-aloud protocols provide valuable data with regard to why users are performing certain actions. This data is an important supplement to the objective data capture of the performed actions through observation, performance measurement, data logging or video.

The instructions for getting users to think aloud have to be given before starting and repeated during the session.

The verbalizations can be concurrent (i.e. spoken while the user works with the system) or retrospective (user voices her/his comments after the task has been completed, with or without the option of viewing a video recording of the actions carried out). Concurrent verbalizations are usually preferred by experimenters because they eliminate the possibility of the users being selective in their recall or introducing after-the-event rationalizations.

The advantages and disadvantages of this method are as follows.

Advantages

— Quick to conduct;

— collects insights into users' mental process;

— flexible, allows probing per users' responses.