The Standard of User-Centered Design and the Standard Definition of Usability: Analyzing ISO 13407 against ISO 9241-11

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ABSTRACT
ISO 9241-11 and ISO 13407 are two important standards related to usability: the former one provides the definition of usability and the latter one guidance for designing usability. We carried out an interpretative analysis of ISO 13407 from the viewpoint of the standard definition of usability from ISO 9241-11. The results show that ISO 13407 provides only partly guidance for designing usability as presumed by the definition. Guidance for describing users and environments are provided but very limited guidance is provided for the descriptions of user goals and usability measures, and generally for the process of producing the various outcomes.

Keywords
Usability, user-centered design, human-centered design, usability engineering, standards

INTRODUCTION
Probably the best known definition of usability is by Nielsen: usability is about learnability, efficiency, memorability, errors, and satisfaction [16]. However, the definition of usability from ISO 9241-11 (*Guidance on usability*) [11] – "*the 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*" - is becoming the main reference of usability. In addition that it is largely recognized in literature, this 'standard' definition of usability is used in the recent Common Industry Format, CIF, for usability testing [1]. This is a very clear indication of the importance of the definition since the creation of CIF was supported by a number of corporations and other important stakeholders.

To improve the usability of software and information systems, the paradigm of user-centered design[1], UCD, has been proposed by a number of method and methodology books, starting from Nielsen [16] to ones published in late 90's, [8], [4], [5], [15] and ending up with a set of very recent ones, [17] and [18].

ISO 13407 [9], *Human-centred design processes for interactive systems*, is a standard that provides guidance for user-centered design. ISO 13407 can be regarded as an important supplement to the UCD literature. First, as a standard, it is based on the consensus of a wide international board of researchers and practitioners of the field. Secondly, it approaches UCD from a higher level of abstraction than most methodology books. Rather than describing different usability methods, it describes usability at a level of principles, planning and activities. A third important aspect is that ISO 13407 explicitly uses the standard definition of usability from ISO 9241-11 as a reference for usability.

One would assume that the setting of two related standards – a widely used definition of usability from one ISO standard and another ISO standard providing guidance for designing usability – would mean that the standards are consistent between each other. Specifically, one would assume that ISO 13407 would clearly take the definition of usability from ISO 9241-11 into account.

This kind of setting makes it interesting to examine the relationships between ISO 13407 and ISO 9241-11. The usefulness and characteristics of ISO 13407 is discussed in papers such as [14] and [6]. The studies in [12] found ISO 13407 useful as a general reference but led to a somewhat different process structure. The earlier research, however, does not explicitly analyze ISO 13407 against the definition of usability from ISO 9241-11. This kind of study, however, would be important for practitioners who wish to apply ISO 9241-11 or ISO 13407 in a particular organization or situation but who do not have time to critically analyze these standards and

[1] Called 'human-centered design' in ISO 13407. Also called 'usability engineering'.

their relationship. Further, the analysis of the standards is useful for establishing a base for further development of guidance for UCD.

In this paper, we present this kind of analysis: examination of ISO 13407 from the viewpoint of the definition of usability from ISO 9241-11. Our analysis is of interpretative nature. We define analytical lenses, and then examine the standard through these lenses. The results of the analysis are based on our interpretations about the text of the standard. In an interpretative study it is important that a reader has a possibility to criticize our viewpoints. For that, we use citations from the standard when we make claims about the standard. Further, we also include longer extracts from some parts of ISO 13407.

In the next section, we interpret the definition of usability from 9241-11 and derive analytical lenses that we use as tools in the analysis. Then we will give an overview of ISO 13407, including citations from the relevant parts from the viewpoint of our analysis. Thereafter, we will present the results of the analysis lens by lens.

THE DEFINITION OF USABILITY FROM 9241-11: DERIVING THE ANALYTICAL LENSES

We first explore the standard definition of usability, and identify the items that should be discussed in a guide such as ISO 13407. Then we discuss the level of guidance that should be provided and form the analytical lenses.

Exploring the Standard Definition of Usability

Usability is defined in ISO 9241-11 [11] as follows:

Usability: *The 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.*

The terms are further defined as follows:

Effectiveness: *the accuracy and completeness with which users achieve specified goals*

Efficiency: *the resources expended in relation to the accuracy and completeness with which users achieve goals*

Satisfaction: *freedom from discomfort, and positive attitude to the use of the product*

Context of use: *characteristics of the users, tasks and the organizational and physical environments*

The concept 'goal' is not defined in ISO 13407, but it is defined in ISO 9241-11. Another relevant concept 'task' is defined in ISO 9241-11, too:

Goal: *intended outcome*

Task: *activities required to achieve a goal*

Generally, this definition of usability is a 'broad' approach to usability [2]: usability is about supporting users in achieving their goals in their work, it is not only a characteristic of a user interface.

The definition means that - first of all - usability is a function of *users* of a product or a system (specified users). Further, for each user, usability is a function of achieving *goals* in terms of a set of attributes (i.e. *effectiveness, efficiency* and *satisfaction*) and *environment of use*.

The definition means that usability is a complex issue. The definition of usability can be elaborated by representing it in a form of a tree, as illustrated in Figure 1.

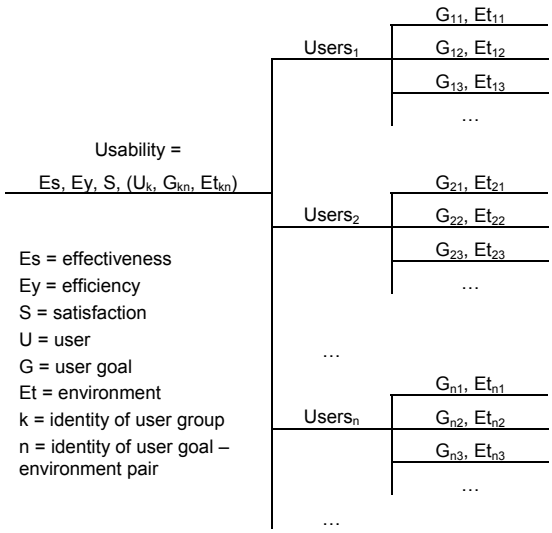

Figure 1. Definition of usability

As an example, one usability measure of a bank machine could be:

- 90 % users achieve the goal (Es) in less than 1 minute (Ey) with an average satisfaction rating '6' (S) when users are novice ones (U), and they want to have a desired sum of cash withdrawn (G) with any bank machine (Et).

A slightly less complex interpretation of the definition is to relate the satisfaction measure to the overall use of a product. For example, the case studies of using CIF in the European PRUE project interpreted satisfaction in this way [3].

The analytical lenses

The analysis of the definition of usability shows that one needs to determine the following outocomes when the definition is used in a development project:

(1) The users of the system,

(2) Goals of users,

(3) Environments of use

(4) Measures of effectiveness, efficiency and satisfaction.

This means that design guidance such as ISO 13407 should provide guidance for how to determine each of these four outcomes.

ISO 13407 is aimed to provide 'overview' guidance for the planning and management of user-centered design, not to provide detailed coverage of the methods and technique. We find that the following level of descriptions should be provided in an overview guidance:

- Clear *definitions* of the outcomes (deliverables), i.e. what the definitions of users, goals, environments and measures should be like
- Discussion about the nature and challenges of the *process* of producing the outcomes

Outcomes (deliverables) are important to be defined clearly while they are an essential means for communication with project managers [7]. Guidance about the nature and challenges of the process of producing the outcomes are important for understanding and planning the user-centered design process (the aim of the standard). On the other hand, we totally agree with ISO 13407 in the sense that no detailed descriptions of methods or techniques are required.

In summary, our analytical lenses are described in Table 1. Each cell represents a viable issue to be analyzed.

Item	Definition of outcomes	Process of producing outcomes
Identification of users	×	×
Determining goals of users	×	×
Determining environments of use	×	×
Determining measures of effectiveness, efficiency and satisfaction	×	×

Table 1. Analytical lenses

OVERVIEW OF ISO 13407

ISO 13407 is an international standard established in 1999. The standard "*provides guidance on human-centred design activities throughout the life cycle of computer-based interactive systems*". The standard aims at "*those managing design processes*" and does not provide detailed coverage of methods and techniques.

ISO 13407 describes user-centered design from four different aspects:

- Rationale for UCD
- Planning UCD
- Principles of UCD
- Activities of UCD

Rationale. The rationale part briefly describes the benefits that usable systems provide, such as reduction of training and support costs, improved user satisfaction and productivity of users.

Principles. The standard identifies four general principles that characterize user-centered design, and that are not bound to any specific phase of development cycle:

- The active involvement of users and a clear understanding of user and task requirements
- An appropriate allocation of functions between users and technology
- Iteration of design solutions
- Multi-disciplinary design

Planning. The planning part provides guidance in fitting user-centered design activities into the overall system development process. Among other things, the standard emphasizes that project plans should reserve time and resources for iteration and user feedback. The importance of teamwork and communication is also mentioned.

Activities. The core of the standard – stated explicitly– is the description of user-centered design activities. The standard identifies four main activities of UCD, illustrated in Figure 2:

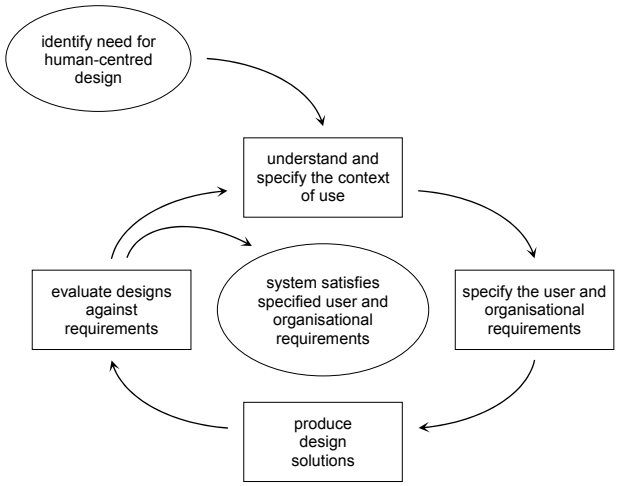

Figure 2. Activities of user-centered design

The activities can be briefly described as follows:

Understand and Specify Context of Use. Know the user, the environment of use, and the tasks that he or she uses the product for.

Specify the User and Organizational Requirements. Determine the success criteria of usability for the product in terms of user tasks, e.g. how quickly a typical user should be able to complete a task with the product. Determine the design guidelines and constraints.

Produce Design Solutions. Incorporate HCI knowledge (of visual design, interaction design, usability) into design solutions.

Evaluate Designs against Requirements. The usability of designs is evaluated against user tasks.

The standard describes the activities informally, each in 1-3 pages. In the next section, we provide the extracts of descriptions of some of the activities.

THE ANALYSIS

In this section, we first present the scope of the analysis, then the results lens by lens, and finally give a summary.

Scope of the Analysis

Usability is one type of a quality characteristic in a product [10] among others, such as functionality, efficiency, reliability, maintainability and portability. In the requirement phase, when the quality requirements for a product are determined, also the usability requirements should be determined.

While all activities of life-cycle are relevant in the design of usability, the definition of usability has a critical impact especially in the requirements phase of a development project. The outcomes of these requirements activities (identification of users, goals, environments, usability measures) provide direction for the design phase and basis for planning evaluations.

The way, in which usability requirements are defined in a development project, totally depends on the definition of usability that is used. For example, if Nielsen's definition of usability is used, usability requirements might be determined with attributes such as errors or remembering[2]. The definition from ISO 9241-11 leads to a different style of determining usability requirements. Therefore, the guidance that is provided in the standard for the requirement phase of the UCD life cycle needs to be analyzed carefully.

Two activities relate to determination of usability requirements: 'Understand and specify the context of use', and 'Specify the user and organizational requirements'. Our analysis is mainly based on examining the descriptions of these two activities.

To make it easier for the reader to challenge our viewpoints, we include the extracts of descriptions of these two activities the following.

Understand and specify the context of use

The standard describes the activity 'Understand and specify the context of use' as follows:

The characteristics of the users, tasks and the organizational and physical environment define the context in which the system is used. It is important to understand and identify the details of this context in order to guide early design decisions, and to provide a basis for evaluation.

Information should be gathered about the context of use of new products and systems. If an existing system is upgraded or enhanced, this information may already be available but should be checked. If there are extensive results form user feedback, help desk reports and other data, these provide a basis fro prioritizing user requirements for system modifications and changes.

The context in which the system is to be used should be identified in terms of the following:

a) The characteristics of the intended users: relevant characteristics of the users can include knowledge, skill, experience, education, training, physical attributes, habits, preferences and capabilities. If necessary, define the characteristics of different types of users, for example, with different levels of experience of performing different roles (maintainers, installers, etc).

b) The tasks the users are to perform: the description should include the overall goals of the use of the system. The characteristics of tasks that can influence usability should be described, e.g. the frequency and the duration of performance"…. Tasks should not be described solely in terms of the functions or features.

c) The environment in which the users are to use the system: the environment includes the hardware, software and materials to be used. Their description can be in terms of a set of products, one or more of which can be the focus of human-centred specification or evaluation, or it can be in terms of a set of attributes or performance characteristics of the hardware, software and other materials. Relevant characteristics of the physical and social environment should also be described. These can include relevant standards, attributes of the wider technical environment, the physical, ambient, legislative and the social and cultural environment.

The output from this activity should be a description of the relevant characteristics of users, tasks and environment, which identifies what aspects have an important impact on the system design. (See ISO 9241-11 for more information about the context of use and a sample report.)

The context of use description should

a) Specify the range of intended users, tasks and environments in sufficient detail to support design activity;

b) Be derived from suitable sources;

c) Be confirmed by users or if they are not available, by those representing their interests in the process;

d) Be adequately documented;

e) Be made available to the design team at appropriate times and in appropriate forms to support design activities.

[2] In practice, Nielsen's attributes as such are too ambiguous to be used in determining the usability requirements.

Specify the user and organizational requirements

The standard describes the activity 'Specify the user and organizational requirements' as follows (some irrelevant text not included):

In most design processes, there is a major activity specifying the functional and other requirements for the product or system. For human-centred design, this activity should be extended to create an explicit statement of user and organizational requirements in relation to the context of use description. The following aspects should be considered in order to identify relevant requirements:

a) Required performance of the new system against operational and financial objectives;

b) Relevant statutory or legislative requirements, including safety and health;

c) Co-operation and communication between users and other relevant parties;

d) The users' jobs (including allocation of tasks, users' well-being, and motivation);

e) Task performance;

f) Work design and organization;

g) Management of change, including training and personnel to be involved;

h) Feasibility of operation and maintenance;

i) The human-computer interface and workstation design.

User and organizational requirements should be derive and objectives set with appropriate trade-offs identified between the different requirements.

The specification of user and organizational requirements should:

a) Identify the range of relevant users and other personnel in the design;

b) Provide a clear statement of the human-centred design goals;

c) Set appropriate priorities for the different requirements;

d) Provide measurable criteria against which the emerging design can be tested;

e) Be confirmed by the users or those representing their interests in the process;

f) Include any statutory or legislative requirements;

g) Be adequately documented.

Results

We present the results outcome by outcome, examining both the definitions of the outcomes and process of producing the outcomes.

Identification of Users

While the term 'user' is widely used throughout the standard, guidance related to identification of users is – quite logically - limited to the activity 'Understand and specify the context of use'.

Definition. In regard to the outcomes, the standard refers to ISO 9241-11 which provides a list of potential user characteristics that can be used in the descriptions of users: primary/secondary/indirect users, product skill, task experience, age, gender, etc. In addition, it is described, "*The context of use description should specify the range of intended users*". One can conclude that the standard provides rather clear guidance about the outcomes related to users.

Process. When examining the description of the activity of determining users, one can see that the guidance has emphasis on determining the *characteristics* of users rather than determining who they are. The description includes statements such as: "*The context of use ... should be identified in terms of ... the characteristics of the intended users*"; and "*The output from this activity should be a description of the relevant characteristics of users*". Identification of different users is mentioned rather weakly and indirectly: "*If necessary, define the characteristics of different types of users*".

In summary, ISO 13407 provides quite clear guidance of what should be produced: descriptions of different users. The standard, however, does not provide much descriptions of the challenge of how to identify the different users. This is a shortcoming because the identification of different users and categorization of them into appropriate user groups is not a trivial thing. The large number of different potential user attributes means that, in practice, it is necessary to do some abstractions.

Determining User Goals

One would assume that user goals would be discussed in the description of the activity 'Understand and specify the context of use'. However, the term 'goal' is referred explicitly only once and rather unclearly: "*the description should include the overall goals of the use of the system*".

Definition. The context of use description – the outcome of the activity 'Understand and specify the context of use' – does not include the word 'goal'. Instead, user tasks are included in the context of use description. Still, these two concepts are different things (see the definitions in the beginning of this section).

Process. The description of the activity mostly refers to tasks: "*The context of use… should be identified in terms of ... the tasks the users are to perform*"; "*the output from this activity should be a description of the relevant … tasks*", and "*The context of use description should specify the range of ... tasks*".

Our conclusion is that the standard is unclear in relation to user goals. Definition of goals is not a part of the context of use description, and the challenges related to the determination of goals are not discussed.

The fact that different users typically have different goals is not discussed at all. Discussion of tasks does not help much. The definitions of these two terms from ISO 9241-11 show that the terms are different things and there is a clear relationship: goals are the ultimate things and tasks are means to achieve the goals.

Environments of Use

Definition. The activity 'Understand and specify the context of use' includes rather extensive discussion about environments of use, including descriptions of different kinds of environments: "*…the environment includes the hardware, software and materials to be used. Their description can be in terms of a set of products, one or more of which can be the focus of human-centred specification or evaluation, or it can be in terms of a set of attributes or performance characteristics of the hardware, software and other materials. Relevant characteristics of the physical and social environment should also be described. These can include relevant standards, attributes of the wider technical environment, the physical, ambient, legislative and the social and cultural environment. The output from this activity should be a description of the relevant characteristics of users, tasks and environment which identifies what aspects have an important impact on the system design*". The fact that environments of use may differ from user group to another and from user task to another is not discussed.

Process. There is no guidance provided about the process of determining the environments.

We can conclude that ISO 13407 provides rather extensive guidance for definition of environments of use. We also conclude that at least some of the environmental issues to be determined – such as hardware and software – are so concrete that the definition of the outcome works as a guideline for the process.

Determining Measures for Effectiveness, Efficiency and Satisfaction

Definition. 'Effectiveness, efficiency and satisfaction' are an elementary part of the definition of usability, but these concepts are not mentioned in the descriptions of the activities related to requirements determination. Especially, one would expect to find guidance for determining effectiveness, efficiency and satisfaction in the description of the activity 'Specify the user and organizational requirements'. However, the issue is addressed only with a rather broad statement: "*The specification of user and organizational requirements should ... provide measurable criteria against which the merging design can be tested*". One would expect an explicit reference to ISO 9241-11 where these measures are described in detail. This reference, however, is missing.

Process. The challenges related to the process of determining the measures are not discussed at all. Especially, one would assume some discussion about the complexity of the task. It is practically impossible to produce usability measures that would cover even nearly the aspects of usability of a system.

Summary

The results of our analysis show that ISO 13407 provides some but only limited guidance on taking the standard definition of usability into account in a development project, Table 2. ISO 13407 provides useful descriptions of the definitions of users and environments. Descriptions of measures of effectiveness, efficiency and satisfaction are not provided, but they can be found from ISO 9241-11(although a clear reference is missing). The definition of user goal is not discussed.

We find as a major shortcoming that the standard includes only very little discussion about the challenges of producing the different outcomes. ISO 13407 does not address the general complexity and specific challenges related to systematic identification of different users, identification of the different goals that users may have; nor determination of measures (effectiveness, efficiency, satisfaction) of usability. The determination of environments of use is addressed in most detailed manner.

Item	Definitions of outcomes	Process of producing outcomes
Identification of users	××	-
Determining goals of users	-	-
Determining environments of use	××	×
Determining measures of effectiveness, efficiency and satisfaction	×	-

×× = description provided
× = limited description provided
- = no description provided

Table 2. Summary of the results

DISCUSSION

ISO 9241-11 and ISO 13407 are two important standards related to usability: the former one provides the definition of usability and the latter one guidance for designing usability. We carried out an interpretive analysis of ISO 13407 from the viewpoint of the standard definition of usability from ISO 9241-11. The results show that ISO 13407 provides only partly guidance for designing usability as presumed by the definition. Guidance for describing users and environments are provided but very limited guidance is provided for the descriptions of user

goals and usability measures, and generally for the process of producing the various outcomes.

Limitations

Our research was of interpretative nature. It was based on our interpretation and understanding about the descriptions of ISO 13407 and ISO 9241-11. We have tried to justify our claims and provided citations from the standards. We welcome the reader to challenge our results.

Our focus was on the early phases of development life cycle. The late phases – design and evaluation – are naturally very important activities, too. We find, however, that the definition of usability is specifically critical for requirements determination. If usability requirements are determined using the standard definition of usability, the definition necessarily has an impact on design and evaluation.

Our study is based on the definition of usability from 9241-11. Our selection for the definition was based on its important position among the HCI community. One could ask whether the definition of usability should be examined critically, too. We, however, did not question the contents of the definition. We find that the definition makes sense: usability is about how a product supports the work people in their work or life practices – although 'looks' a bit complex. We found the definition sensible and usable, and providing a good basis for our work.

Implications for Practitioners

ISO 13407 is an important contribution to the community of HCI. ISO 13407 at a general level provides good and relevant guidance to user-centered design. We have used it extensively, and we recommend it as a useful reading to people interested in user-centered design. It describes well many of those activities and phenomena typical to user-centered design. As a standard, it is an authoritative reference.

Our analysis shows, however, that ISO 1307 does not take all aspects of the definition of usability from 9241-11 into account. Our message to practitioners on the basis of this study is that ISO 13407 alone is not adequate guidance for using the standard definition of usability in a development project.

We have, quite successfully, tried an approach where we determined usability requirements simply following the standard definition of usability: we first identified user groups, then user goals, and finally usability requirements in terms of effectiveness, efficiency and satisfaction. Among other things, the complexity of usability became very apparent. To manage this complexity, we excluded the consideration of environments in the process.

Anyway, we found this kind of approach useful. It is better to 'determine usability requirements' somehow than not to determine them at all. We determined usability requirements in multi-disciplinary workshops. They proved to be effective ways to incorporate the existing user knowledge of the development team into the requirements, and to mutually share the results. This process is described in [13].

Using the definition of usability as a guideline for usability process means a new direction in usability work among many practitioners. Usability efforts and challenges are directed to determination of usability requirements rather than for example usability evaluation and testing. We find this basically as a positive sign: through measurable usability requirements the usability work of the projects becomes more recognized and goal-driven. Another aspect is that this kind of approach leads to measurable usability. Making things measurable is a very essential aspect in development cultures where "what is measured gets to be done".

Proposals for Enhancements

We propose that general guidelines for user-centered design – such as ISO 13407 – should clearly define all the key terms, and be consistent when using the terms. For example, the use of the terms 'goal' and 'task' should be made more consistent in ISO 13407. As another example, we propose using 'environment of use' rather than 'context of use' in the definition of usability (the context of use includes unnecessary redundancy).

The definitions of outcomes (deliverables) should be clearly described. The definition of usability presumes that descriptions of users, goals, environments and measures of usability should be produced. Clear guidance – and examples of different options – should be provided.

The guidelines should emphasize the fundamentality of the production of the outcomes. The general complexity of the process of producing the outcomes should then be discussed. Descriptions of typical features of the process – such as iteration, user involvement, and cross-functional teamwork - should be provided as means of achieving valid outcomes.

Further Research

Our experience is that practitioners appreciate guidelines that are clear and concrete, but also allow space for different ways of implementing the usability process.

Our analysis as well as our practical experience indicates that there is a need for advances also in the level of methods and techniques of the usability process. Not too much research results exists on how to manage the inherent complexity of determining usability requirements. Typical products have many different users; each of them may have different goals; the levels of sufficient effectiveness, efficiency and satisfaction may vary between users and goals. It is hard to imagine that an ideal solution would exist to this problem. However, there is a real need in practice to have some kind of systematic way to tackle this challenge of complexity.

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