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Stakeholder logistics of an interactive system

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ABSTRACT

Although it seems that software metrics have moved beyond mere performance measurement, it is not too clear how machine effectiveness, efficiency, and effort pertain to human requirements on such matters. In industry as well as academia, the ISO 9241-11 norm provides the dominant view on usability, stating that usability is a function of effectiveness, efficiency, and satisfaction. Although intuitively, usability requirements should be part of a software's design in an early stage, conceptually and empirically, it seems more likely that performance requirements (i.e., the absence of errors) should be the center of concern. This paper offers an elaborated view on usability, satisfaction, and performance. Certain theoretical conceptions are tested with data gathered from professional users of banking and hospital systems by means of a 4-year single-item survey and a structured questionnaire, respectively. Results suggested that performance factors (i.e., efficiency) are more important than usability in understanding why stakeholders are satisfied with a system or not. Moreover, it neither is dissatisfaction with a system nor that a system is less usable that predicate requirements change. Instead, avoiding machine inaccuracy best predicted the variability in agreement to "must have" requirements, while achieving human accuracy predicted the variability in agreement to the "won't have" requirements. The present contribution provides a consistent research framework that can bring more focus to design (i.e., prioritization), clarify discussions about design trade-offs, makes concepts measurable, and eventually may lead to better-informed designs.

1. Introduction

In requirements engineering, there is a fundamental problem in trying to achieve rigor in treating usability, because this term has come to be a catchall for any user-related aspect of an interactive system, or for any method of evaluating these aspects of the system. Overall usability is rarely discussed during design. Instead designers usually focus on specific features of the interface, their consistency with other features (as a heuristic for reducing errors and easing learning), the reduction of unnecessary steps in performing tasks (as a heuristic for reducing task time), and any other design defect that emerges from analytical or empirical requirements evaluation.

It is a moot point whether this feature-based approach to design is the right approach, and one could argue that designers should pay more attention to measurable properties. Defining a system's usability should be one of the central activities during requirements development (Jokela et al., 2003). According to ISO 9126 (1991), usability, like reliability and maintainability, is one of the quality requirements of a system. To verify the expected success of a design, the measuring of usability and related concepts deserves some attention as well (Nielsen and Levy, 1994). Measurable usability requirements are important because "what is measured gets to be done" (Jokela et al., 2003).

Yet, before new design methods can reasonably be introduced it is important to find out how usability in general relates to user satisfaction. In addition, in what way is satisfaction affected by the effectiveness of a system, directly or via usability? And how does efficiency fits into this constellation, and how effort?

Knowing the general structure of the factors that contribute to user satisfaction – how they relate to one another – is important not out of scientific interest alone but also because it can bring focus to design. If pushing two buttons instead of three increases the chance that the patient dies, effectiveness has priority over usability. By contrast, if satisfaction with a system is purely based on ease of use then why bother too much about speeding up the CPU?

One of the contributions of the current paper is a model for understanding issues of usability and satisfaction, based on effectiveness, efficiency, and effort, as influenced by the emotion sustaining factors *relevance* and *valence*. Relevance pertains to the importance of a system's feature to stakeholder goals and valence to the possible prospect of gains or losses of applying or using that feature. The model hypothesizes that satisfaction is dependent on usability, etc. in contravention of the ISO 9241-11 definition (ISO,

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1998), which assumes the reverse, that usability is dependent on satisfaction, effectiveness, and efficiency. Effort is left out of the picture by ISO 9241-11.

I derived this model by a conceptual analysis of the literature and where the literature was unclear or where things were missing, I attempted to create my own solutions. Researchers have made several attempts to analyze the meaning of usability (e.g., ISO 9241-11, 1998; Van Welie et al., 1999; Jokela et al., 2003) but they admit that the concept of usability is confused (Van Welie et al., 1999), used inconsistently (Jokela et al., 2003), and may vary for different stakeholder groups, and under different contexts of use (Jokela et al., 2003). Nearly all researchers acknowledge that usability is a multifaceted concept (e.g., Jokela et al., 2003) and in treating usability factors, authors therefore tend to come up with a diversity of bulleted lists. My aim is to construct a systematic requirements theory of usability and related factors that can be empirically tested. The general mix-up in terminology and meaning in the literature forced me to present the new model up front as derived from first principles (e.g., logic, other theory and/or definitive studies). At that point, I will review whether and how others agree with it. I do this for the overall model called Stakeholder Logistics, and repeat the same procedure for each sub model that the main model consists of, namely the model of Effectiveness, Efficiency, and Effort. In addition, I will introduce the so-called Relevance-Valence Moderator Box. It turned out that usability is such a complicated issue that the two field studies I conducted validate some aspects of the main and the sub models but definitely not all.

Note in this respect that the scope of my treatment of usability and satisfaction is limited to performance (i.e., effectiveness, efficiency, and effort). It does not concern so much aspects of esthetics or learnability. Although these factors could easily contribute to usability and satisfaction, their inclusion would make the model even more intricate.

Three principles guided my construction of Stakeholder Logistics and its sub models. The first principle is probably rather unproblematic and that is the idea that satisfaction is a property of the user, a subjective judgment therefore. The same goes for usability, I suppose, so that what the designer deems usable does not have to match what the user thinks is usable. Effectiveness, efficiency, and effort also are judgments; they are not properties of the machines people work with. A computer is not fast; it can have a processing speed of 60 Hz or 600 Hz but humans judge that as slow or fast. The first principle, then, is that the model is about human judgments that are based on physical variables, such as time, error rate, number of hits and misses. The second principle is related to the first. In computer–human interaction, both humans and machines perform the work. Whether the machine executed its job fast or slow, whether the user was effective or not, are different judgments. In other words, a theory of usability and satisfaction should combine judgments on the machines with judgments on humans working with those machines. The third principle is a fine-tuning of the other two. Subjective judgments are perceptually and emotionally biased: Judgments of fast or slow are relative to previous experiences. Processor speed of 60 Hz is fast if before it was only 40. A bad experience appears to take longer than a pleasant experience even if the amount of clock time is the same. By the same token can conflicting judgments run in parallel: Although a long waiting time for connecting to the Internet feels negative, using that time to pour a cup of coffee may feel positive.

2. Stakeholder Logistics

Central to almost all usability discussions are the ISO 9241-11 norms (ISO, 1998), featuring the citation that usability is "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction." This

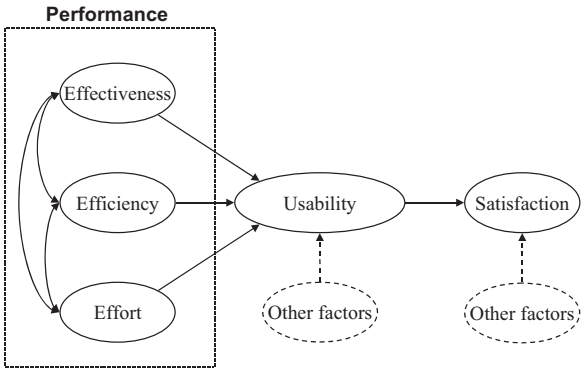

Fig. 1. Model of Stakeholder Logistics. Usability of an interactive system mediates between Satisfaction on the one hand and Performance (Effectiveness, Efficiency, and Effort) on the other.

'standard' definition of usability (Jokela et al., 2003) is adopted also by the Common Industry Format for usability testing ANSI/INCITS 354 (2001) (for an overview of usability standards, see Bevan, 2001). Many authors mention one or more factors from the effectiveness, efficiency, and satisfaction triplet as well as some extras such as learnability, customizability, and helpfulness (e.g., Nielsen, 1993; Jordan, 1998).

The role of satisfaction in the usability description of ISO 9241-11 is somewhat obscure. It is unclear whether satisfaction influences the level of usability or usability affects the level of satisfaction. In the first case, satisfaction forms the input for usability like effectiveness and efficiency do. In the second case, satisfaction is the net-result of an effective, efficient, and usable system.

In following ISO 9241-11, Frøkjær et al. (2000) correlated effectiveness, efficiency, and satisfaction with usability but did not establish significant results. Authors such as Brooke et al. (1990) and Frøkjær et al. (2000) conjecture that satisfaction explains usability. Simply put, these authors claim that whatever makes a person happy is usable. However, not everything that makes a person happy is necessarily useful (e.g., the esthetically pleasing color of an interface widget). Yet, all useful things (e.g., a search engine) could possibly make someone happy. That would set apart satisfaction from usability as the ultimate container concept to which usability can contribute just like effectiveness, efficiency, and effort can, but also esthetics, fun, and creativity (cf. Preece et al., 2002, p. 19).

Stakeholder Logistics (Fig. 1) takes the position that satisfaction has no explanatory power because it is the outcome of a process. This counters the position of ISO 9241-11, saying that satisfaction explains usability. In an empirical study, Pather et al. (2003) even went further. They used satisfaction not only to estimate the usability but also the effectiveness of information systems. This view actually implies that while people try to achieve goals (i.e., try to be effective), they are already satisfied. Yet, if they were already satisfied, then why would they want to achieve goals? Scott's (1995) review also indicates that the degree of effectiveness is explaining the degree of satisfaction.

In Fig. 1, then, Usability is modeled as a threefold function of Effectiveness, Efficiency, and Effort. Effectiveness and Efficiency are modeled as independent predictors of Usability and for the sake of simplicity, Effort is modeled in the same way. Satisfaction is conceived of as a dependent measure, being a judgment that covers all kinds of aspects of a system – not usability alone. The model recognizes that other factors (dashed) can contribute to Usability (e.g., learnability) and to Satisfaction (e.g., esthetics) but these fall outside the scope of the present paper. Fig. 1 shows that judgments on Usability are a necessary step to get from Effectiveness etc. to Satisfaction. Scott's (1995) review, however,