



## Can icons enhance requirements engineering work? <sup>☆</sup>



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### ABSTRACT

When novel artifacts are proposed, their usability must be taken into account. We argue that effective visual notation depends critically on its usability, which assists members in more easily communicating with each other while reducing misunderstanding. In this paper, we extend prior research by elaborating already-refined artifacts (requirements engineering modeling, icon-based modeling and user preference modeling), and by carrying out summative (confirmatory) evaluation. The summative evaluation assists in determining artifacts' utility. Employing usability measurements, we examine perceptive, ergonomic, and hedonic qualities. The tests were performed in three series of iterations by two groups of practitioners. The first iteration was assigned to a few selected experts in computer and software companies to execute pre-testing. The second iteration was tested by the rest of the experts in the computer and software companies. The third iteration was examined by PhD students in the Faculty of Information Technology at the University of Jyväskylä. The findings demonstrate the usability of an icon-based approach, integrating altogether three artifacts, that serves users in a novel yet fairly effective manner. We suggest that an icon-based approach could serve as a positive basis on which to construct a requirements engineering visual notation that is easily understood and learned.

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## 1. Introduction

Requirements engineering (RE) is the early part of the software development life-cycle (SDLC). It is a crucial influencer to the success or failure of a software system [1–4]. RE is an attempt to deal with understanding the real-world conditions, determining what capabilities the proposed solution must possess in order to correspond to such conditions, and specifying those capabilities as the final requirements for a system [5]. Principally, RE process consists of many iterative activities, ranging from elicitation, analysis, specification, and verification to management [6]. The effective requirement activities count on the

communication among various background stakeholders such as users and technical staff [7]. Whereas technicians are typically familiar with technical terms, users basically understand requirements within users' domain frame. For instance, in the medical healthcare where physicians proscribe medical instructions in a medical language that is sometimes difficult for unskillful patients to understand such instructions [8]. In the RE domain, there are dozens of methods currently available [9,10]. However, those might not adequately serve RE work in the absence of an easily understandable perspective, and the risk thus remains that current methods do not meet practitioners' expectations [11,12]. Empirical studies (e.g., [7,9,10,13,14]) reveal challenges faced within RE: (1) requirements identification, which refers to the ability of users to express their needs explicitly and concisely, (2) requirements specifications, which are associated with difficulty in understanding and reviewing requirements, and (3) managing requirements, which relates to the effort used to manage, monitor, and

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continue tracing the requirements in the life cycle. Our research therefore aims to gain insight into a novel, desirable alternative that affords to figure out such challenges and enrich RE work.

Icons are small images that perceptually resemble particular functions or objects that convey the certain meanings to diverse stakeholders [7,15]. Icons and symbols have long been part of users' experience in the computer-aided system, and many of them are ubiquitously applied in human–computer interaction (HCI) [16]. Moreover, icons are now applicable in various sectors such as transportation, hotels, healthcare, and airports [17–21]. As an example, traffic signs that adapt iconic concept and colors are universally recognized in almost all countries [17,22]. Iconic notation is also branched to an emerging multimedia, web development, and e-business specification [23,24]. These systems of icons have become a simple language that has the power to capture users' attention and speed up recognition [25,26].

The prior work [19–21,27–29] made an effort to define and develop innovative artifacts: RE modeling, icon-based modeling, and user preference modeling. Integration of these three artifacts is called an icon-based approach. One contribution of previous studies was an introduction of an alternative means that enables stakeholders to specify, communicate, and trace requirements. Another foremost contribution was also to carry out a formative (exploratory) result.

To extend prior-published papers, we elaborate the conceptual models and report the results of summative (confirmatory) evaluation. The evaluation is based on a web-based demonstration that was implemented to illustrate the concept of our icon-based approach. We address two core research questions: (1) How do people of diverse knowledge (experts, working in software companies and novices, newbie in RE) feel about an icon-based approach? and (2) Are the characteristics of the adopted icon-based approach able to enrich RE work? To answer these questions, an examination of the icon-based approach is absolutely essential. The evaluation was aligned to Finnish preferences and tested in three iterations by a total of 16 participants. The first iteration, a pre-test to ensure its potential in practice, was performed by two expert participants. The second iteration was evaluated by nine expert practitioners in the computer and software company. The third iteration was appraised by five PhD students from the Faculty of Information Technology at the University of Jyväskylä.

The following section presents prior work on which we based our method for designing an icon-based approach. In Section 3, we describe our methodology and in Section 4 the theoretical background to icon-based approach with three developed artifacts is explained. In Section 5, we illustrate the technical implementation of our demonstration. In Section 6, we describe an experimental evaluation of the demonstration. Finally, Section 7 discusses the result and Section 8 concludes the paper.

## 2. Related work

This section provides some necessary background and related work starting with the prominent methods widely

used in RE and followed by a clarification of the extent of applications in which icons are regularly utilized. This section ends with a consideration of the cultural aspects that influence user perception of icons.

### 2.1. RE environment

While several graphical notations for RE have been suggested, the ubiquitous success of UML [30] and the goal-oriented model [12,31] make them two of the most-exercised methods in the RE domain. The goal-oriented model focuses on why systems are constructed in the early analysis or in the elicitation phase of the RE process. Two leading goal-oriented languages are KAOS [32] and  $i^*$  [33]. UML, on the other hand, emphasizes how systems are used and promotes the notion of a scenario [34]. It has been extensively accepted as the industry-standard language for modeling and analyzing requirements [35]. Recently, user requirements notation (URN) has combined the goal-oriented requirements language for non-function requirements and the use case map (UCM) notation for functional requirements into a single notation [36]. This extension allows requirements engineers to discover and specify requirements for a proposed system.

Many researchers have examined modeling languages as a way to improve the RE process so it can be easily understood by various stakeholders [37–40]. Like the approaches in those studies included in [10], the motivation of this research came from an attempt to derive an approach to enrich the communication process among RE stakeholders. This study goes beyond others in how it has enacted icons as a protocol, rather than use other graphical notations of existing modeling languages such as those of UML and the goal-oriented model.

There are also recent studies that pursue the development of visualized tools that enable end-users without technical experience to transmit their requirements [41–43]. Unfortunately, none of these tools uses icons. This study is thus intended to encourage stakeholders involved throughout the RE process to communicate through the capability of icons.

### 2.2. The nature of applicability of icons

Studies (e.g., [16,26,44,45]) designate that icons and pictograms brought into people's living circumstances can essentially fascinate their imaginations. Nowadays, icons are important visible representations of information that significantly mitigate the amount of typing needed when using a computer. Historically, an attempt [46] has been done in developing one international language underlining to the use of icons and symbols to convey messages. The growing body of icon usage in HCI, computer-aided systems or software packages can be seen e.g., [15,16,23,24]. The icon era in interface and screen design began with the Xerox Star computer in the 1970s and continuously broadened with the launch of the Apple Macintosh in the mid-1980s. In graphical user interfaces (GUIs), icons rapidly turned into the essential ingredient when Microsoft adopted icons to its Windows system and software

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