Kim J. Vicente

Cognitive Work Analysis Toward Safe, Productive, and Healthy Computer-Based Work

Book Review

Index Terms—*Cognitive work analysis (CWA), human factors, system management, user-centered design, user interface human factors, work process design.*

—Reviewed by
TIM L. J. FERRIS,
MEMBER, IEEE

This book is already the classic text in the area of cognitive work analysis (CWA), and the author, Kim Vicente, is a recognized expert in the field. CWA is an approach to the problem of understanding the work required to perform complex tasks. The approach was developed at the Ris National Laboratory in Roskilde, Denmark, under the leadership of Jens Rasmussen, head of the electronics department.

Vicente's book is divided into four parts. The introduction argues that work analysis is required to understand large complex systems for the purpose of controlling those systems under both normal and abnormal conditions. CWA enables the designer of the system to understand the various modes of interaction between the operators and the system. Normal system operating conditions are routine and can be handled using algorithmic methods codified in work procedures. However, according to Vicente's argument, abnormal conditions are the very reason why there is a human operator present who can exercise expert judgement in real time rather than resorting to codified procedures. Part 1 is very good because it emphasizes the system design process of establishing that the system's user interface enables correct and safe operation under all circumstances. The emphasis that Vicente puts on the issues of the preliminary phases of system design, including concepts related to operations, user and customer requirements, and user interface design, are valuable lessons for all engineers whose education and mindset often overlook these matters.

In Part 2, Vicente reviews the three families of work analysis methods. The normative approach concerns the presentation of "the one best way" to work. In a system designed around a normative work analysis structure, every possible action is described in complete detail, including the operator actions in the event of every kind of extraordinary situation. Normative work analysis is used in many situations where the outcome is critical because system designers believe they have been able to anticipate and determine responses to all possible unusual circumstances.

Descriptive work analysis investigates "what workers really do." In this case, workers have been introduced to the system and trained in appropriate methods of operation. As workers gain familiarity with the system, they develop modified methods of operation, and these methods are then described. While this method aims to obtain a complete description of the real activity, it does not effectively address the problem of drift from the correct process in process-sensitive situations.

The third approach is the CWA approach, which is a formative approach. The issue in the formative approach is that workers trained in the characteristics of the system and the fundamentals of system control are then relied upon to "finish the design." In particular, the theme that Vicente follows is that the operators finish the design of the operational instructions in the unusual situations where it is difficult for system designers to anticipate the full range of possibilities and to develop appropriate normative instructions to deal with each such unusual situation. Vicente repeatedly uses the phrase "finish the design," and this matter will be discussed later.

Part 3 leads the reader through the process of CWA. The process includes understanding the work domain, the substance of that which the work concerns. Once the work domain is understood, the task of control of the process must be analyzed by defining the normal control requirements and the means that must be available to deal with unusual events. Work domain analysis concerns the development of an understanding of the field of work so that through an understanding of the field, the easiest pathways to solutions of the operator control problem can be found. In this discussion, there is one obvious error of physics on page 153. Fig. 7.2 purports to show the magnetic field around two positively charged particles. The caption is wrong in calling the field magnetic and not electric, and the figure itself shows a wrong set of "field" lines for either electric or magnetic fields. The error detracts from the substance that was illustrated.

The next phase is control task analysis, which concerns the understanding of what must be done in the normal operation condition and the process of control required in this situation. The third phase is strategies analysis, which concerns how normal control is done through development of information flow maps. INFORMATION FLOW MAPS show the associations of ideas that are found in the work domain. The fourth phase analyzes the social organization and cooperation required to complete the task. This analysis concerns the distribution of subtasks among the members of a team, which then affects system design through matters such as the distribution of the user interface among the operator workstations. The final phase is analyzing the worker competencies required for successful operation. This is an early stage of analysis in other methods of work analysis, but in CWA, it is delayed until the various aspects of the work have been explored.

The book is pleasantly written as a text and so enables a reader unfamiliar with the detail of CWA to use this book to develop a significant knowledge of the area. The book includes a very extensive reference list, on the order of 450 items, of the research literature related to CWA, thus enabling the reader to explore the historic development of CWA and to follow leads into greater detail about various aspects of the method. For this reason, and the discussion of matching the system to the user, I recommend the book to engineers as a book that will extend their thinking about the issues of user interface to systems and usability in general.

However, there are some weaknesses in the book. In the preface, Vicente says that the book does not provide procedural guidance for application of CWA, nor practical advice on how to implement the framework in industry, nor formalisms to codify the concepts of CWA, nor computer-based tools to reduce the effort required. At first glance, these limits on the extent of the book appear reasonable. But I now move to discuss the problems introduced by these limitations of scope and aim in the book.

The introductory section discusses the system design motivation of CWA, and the later sections discuss the method, but there is a disconnect between the two aspects within the book. The result is that the book contains two themes: the need to consider user and interface issues and the CWA method of analyzing work. There is no explicit link made between the two themes.

The absence of practical advice on how to apply CWA in industry results in the impression that CWA is a method applied only in tabula rasa situations, where there is no legislation constraining the work process or interface and no tradition of similar products where confusion may be caused by requiring worker transition to a new user interface. Examples of work domains where such constraints currently exist include the civil aviation industry and desktop computer interfaces. Substantial discussion of how to address these issues would make the book much more valuable.

Another weakness in the book as a communication device for the concept of CWA is found in the frequent repetition of the phrase workers "finish the design" in relation to the use of skilled operators to determine the most appropriate process to address unusual or unexpected situations. The repetition of a catchy rhetorical form to convey this concept creates a special danger. Practitioners of CWA may become lazy in their investigation of the relationships inherent in the work domain if the mantric repetition of this phrase sends a subliminal message that the CWA analyst does not need to elaborate on likely and possible system malfunctions. Thus, CWA could lead to conclusions that do not particularly enlighten the design of the system.

These weaknesses in the book have caused CWA to become controversial. The book is valuable for engineers because it opens

up a new way of thinking about the analysis of work tasks and, consequently, the user interface issue and the systems design question. However, the book cannot be read as the whole truth because it was never intended to cover everything. Considerable caution and creativity are required to use the ideas presented.