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# Reducing cognitive workload of a computer-based procedure system

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**Abstract**

The use of procedure systems is an important safety management strategy in coping with emergency or abnormal situations in a process control system. With the digitalization trend in these complex and large-scale systems, most aspects of a process control system are also computerized. In addition to the primary tasks, operators now have to do extra secondary tasks when using the computerized systems. In this research, three design features aimed to reduce the cognitive workload are evaluated on our research platform, SimCBP and SimPlant. These two systems work in tandem to simulate a Computer-Based Procedure (CBP) system and a simplified nuclear power plant. From the results of the experiments, the design of embedded controls/parameters is found to be efficient but its counterpart has implications for the design of training materials. Navigation aid, although not statistically significant, is important because of the subjective responses and the need of cross-referencing. The simplified flowchart display format, like other researches on the use of this format, revealed mixed results. Implications and directions for future studies are also proposed.


*Keywords:* Computer-based procedure; Nuclear power plant; Navigation aid; Embedded controls/parameters; Flowchart

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## 1. Introduction

To enhance the operational safety and reliability in plants, factories, or complex and large-scale systems, operating procedures are often employed to aid the crew in carrying out their tasks. Operating procedures are pre-formulated sets of decisions and actions that personnel can follow to monitor the system in normal situations and to diagnose the system in abnormal and emergency situations. It is especially important to have properly designed operating procedures for abnormal and emergency situations because catastrophic accidents might happen.

From a macro point of view, the design of operating procedures can be approached from two aspects: (1) the technical accuracy of the procedure and (2) the general design of the procedure. The technical accuracy of the procedures is ensured by scientists or engineers of related domains, while the general design should be examined by Human Factor specialists. The general design encompasses Human–Computer Interface, presentation formats, cognitive supports and many other issues that facilitate the efficient and effective use of the operating procedure. We will focus on the general design issues in this research.

Traditional operating procedures are paper based. They are usually bulky, become outdated very soon and get dirty due to frequent uses. Thanks to advances in information technology, operating procedures are computerized and evolving into a better supporting role during emergency or abnormal operations. However, computerized operating procedures are not perfect. For example reading on Video Display Unit (VDU) is not as easy as it is on paper; the amount of information that can be legibly displayed on VDUs is limited. Even worse, using the computer system incurs cognitive and physiological loads. To make Computer-Based Procedures (CBPs) really useful, we must tackle the deficiencies of CBPs. Our approach is based upon the concept of cognitive tasks of an operator, as shown in Fig. 1, where the operator plays as a supervisory controller. Cognitive tasks of an operator can be classified into primary and secondary tasks, where primary tasks include monitoring and detection, situation assessment, response planning and response implementation. Secondary tasks include interface management, search and communication. The operator interacts with the system and automatic control system through the Human–System Interface, during which the cognitive system is taxed and the cognitive overload might occur as a consequence. Cognitive overload is caused by four types of causes: (1) too much information supplies, (2) too much information demands, (3) the need to deal with multi-tasking and interruption and (4) the inadequate workplace infrastructure (Kirsh, 2000). In the demanding systems mentioned above, cognitive issues should be carefully considered during the design and implementation of the systems.

Computerized operating procedures can be very useful while the operator carrying out primary tasks. For example dynamic plant parameters can be embedded directly in the content, and the trends and changes of these parameters can be visualized for better understanding and evaluation of the current status. CBPs can also provide