DESIGNING EPSS FOR THE MARINE INDUSTRY

Dr. Ashok Banerji
Interactive Multimedia Centre, ESD Department

Mr. Rajan Bhandari
Maritime Technology and Transportation Department

Singapore Polytechnic, 500 Dover Road, Singapore 139651
Tel: + (65) 772-1496 Fax: + (65) 772-1954
email: a.banerji@sp.ac.sg

Abstract

Casualty investigation statistics show that nearly 80% of all shipping accidents are caused by human performance error. The major task facing the shipping industry therefore is to improve the quality of performance and decisions on board ships and ashore. However it is difficult because of the very nature of the industry, namely: (a) reduced staffing and demanding sailing schedules; (b) numerous equipment performing similar functions but differing significantly in operation and technology; (c) high turnover of personnel; (d) insufficient time for familiarisation with equipment and training; and (e) frequent transfer on ships with different machinery.

As a strategy to improve task performance under situations similar to above the concept of electronic performance support system (EPSS) have been proposed. An EPSS helps to structure on-the-job learning and can drastically reduce the cycle time from when a performance gap is identified until the gap is closed for the entire population. The paper examines the EPSS approach and identifies the critical areas where it can be adapted for the marine industry. A framework for design has been described along with an example.

1. INTRODUCTION

Developments in computer technology are rapidly transforming the methods in which information is distributed and retrieved; knowledge and expertise is stored and acquired; and skills are learnt and transferred. These have important impacts in engineering training and skills development in order to meet the challenges of handling complex plants and equipment (Banerji and Bhandari, 1995). The advent of multimedia technology has meant that many new approaches to instructional and information delivery can be implemented. These resources can be amalgamated in a suitable way to create electronic performance support systems (EPSS). The EPSS approach is currently gaining much attention and is being used in variety of industrial situations (Banerji, 1995). However, nothing has been reported about EPSS for the marine industry. This paper first describes the basic tenants of the approach. The particular requirements of shipping industry are examined and finally an EPSS development framework is suggested.

2. RATIONALE FOR PERFORMANCE SUPPORT

In order to understand EPSS it is necessary to consider the factors which influence the time it takes a human to perform a task within a given application domain. In general, the total time taken to perform a task ($\mathbf{T}_{task}$) depends on two basic factors. First, the time to find a method ($\mathbf{T}_{method}$); and second, the time for the actual execution of the task ($\mathbf{T}_{execute}$). That is,

$$\mathbf{T}_{task} = \mathbf{T}_{method} + \mathbf{T}_{execute}$$

One of the most important features of an EPSS will be its ability to minimise the overall task performance time. In order to fulfill this requirement it is necessary to identify which of the factors in the above equation has the largest effect in limiting performance. Design can then proceed so as to remove any limitations that are found.

Within a human-computer system the time to execute a task will depend upon whether it has to be performed by the human element or the machine component. If it is undertaken by a machine then installing faster equipment can usually improve performance. If the task is executed by a human then skill enhancement (through training) or the provision of a performance support aid might help to improve efficiency, hence overall performance. This situation is identifiable within the marine industry and has led us to propose the '**EPSS for marine operations**' as will be discussed later.

Similar arguments to those presented above apply in the case of finding a method to perform a task. This responsibility normally falls on the human element of the system - although, in some highly automated systems it can be allocated to the computer. There are four basic ways by which a person could obtain a method to fulfill a task: **recall**, **search**, **learn**, and **devise**. Appropriate design of an EPSS can be used to minimise $\mathbf{T}_{method}$ for each of these approaches. If the method that is needed for a particular task is one which is frequently used then it is likely to be recalled easily - thereby giving a minimal $\mathbf{T}_{method}$. However, if it has to be searched for (either in long term memory or within some book, library or on-line system) then $\mathbf{T}_{method}$ is likely to increase substantially. If a method cannot be recalled or found by search then an appropriate one will have to be learned. If a suitable method for handling a task does not exist then an appropriate one will need to be devised; this situation can lead to maximal values of $\mathbf{T}_{method}$. The '**EPSS for marine regulations**' (discussed later in this paper) addresses this aspect of performance support.

Besides reduction in task performance time the other important functions of a performance support system are reduction of operational error and improving the quality of task performance. These can be achieved through appropriate design of an EPSS (Banerji, 1995, Barker, 1996).

3. EPSS DESIGN MODEL

Nowadays, in most modern workplaces computers are used for decision-making, task performance and also planning - thereby, replacing many manual methods. The work is done neither by people nor by computers alone but by 'man-computer' systems (Singleton, 1974). In these situations computers act as a powerful tool by providing an interface to the basic job tasks that are involved. Humans and computers thus tend to work cooperatively and symbiotically (Licklider, 1960) - combining the advantages of the powers of each in order to achieve more effective job performance. This in fact, forms the basis for the current growth of interest in EPSS. The concern of an EPSS is effective **human-task interaction** in which the computer provides an interface to various job tasks and becomes an effective aid in achieving efficient task performance. An EPSS is thus defined as *'a human-computer activity system that is able to manipulate large amounts of task related information in order to provide both a problem solving capability as well as learning opportunities to augment human performance in a job task by providing information and concepts in either a linear or a non-linear way, as and when they are required by a user'* (Banerji, 1995).

When designing an EPSS it is important to understand those aspects of human performance that most often need to be augmented. Annett (1983) suggested that the knowledge-based component of a job specific skill is most vulnerable to forgetting and that this often constitutes the major part of skill loss. He identified five major types of forgetting: facts, tasks, mis-remembering, rusty skills, and absent-mindedness. None of these types of forgetting are necessarily complete. For example, people can recall a forgotten fact minutes or days later - or almost immediately when given a suitable cue. One of the design goals of an EPSS is to come to the aid of employees who experience these types of forgetting. An EPSS should also help employees to adapt quickly and to learn new processes or changes in procedures and practices. These basic design issues have been discussed elsewhere (Banerji, 1995, Barker and Banerji, 1995). A functional model of EPSS is shown in figure 1.

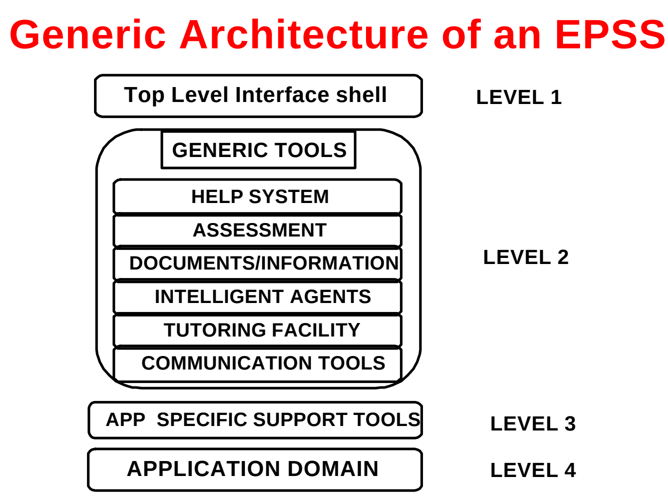

Figure 1: EPSS model

The focus of the EPSS model is on supporting task performance through an array of computer-based support tools providing guidance, expert advice, training, information, and reference material. The EPSS facility makes these available at the point of need while performing a particular job as defined by the just-in-time (JIT) paradigm. Some of the different types of functionality that an EPSS should attempt to provide are listed below:

- rapid access to job related information
- needs-based training
- help, guidance, and advice (user and system initiated)
- reviews of job or task steps and procedures
- skill practice (in a simulated environment)
- optional performance monitoring and advice
- library or information support

This EPSS model is particularly applicable to marine industry because of its operational requirements and characteristics. These are discussed in the remainder of this paper.

4. CHARACTERISTICS OF THE MARINE INDUSTRY

Our rationale for proposing performance support intervention for the marine industry is based upon studies of shipping accidents. For example, "*casualty investigation statistics show that as much as 80% of all accidents can be traced back to procedural reasons, whereas only 20% are directly related to technical failures. In other words 80% of all maritime accidents are caused by substandard acts and about 20% by substandard conditions.*" (Dombey, 1994). Acknowledging the gravity of this finding the International Chamber of Shipping observes - "*while statistical analyses suggest that around 80% of all shipping accidents are caused by human error, the underlying truth is that act or omission of human beings plays some part in virtually every accident, including those where structural or equipment failure may be the immediate cause*" (Card, 1996).

The management and operation of a ship is specialised and complex and is further complicated by: (a) reduced manning and demanding sailing schedules; (b) numerous equipment performing similar functions but differing significantly in operation and technology; (c) high turnover of personnel; (d) insufficient time for familiarisation with equipment and training; and (e) frequent transfer on ships with different machinery. Therefore the International Maritime Organisation (IMO) and national regulatory bodies have introduced standards, conventions and international rules for safety and pollution control including SOLAS (Safety of Life at Sea), MARPOL 78 (Marine Pollution), STCW 95 (Standards for Training and Watchkeeping 95), International Safety Management (ISM) and Load Line.

The STCW 95, came into force in February 1997, is a comprehensive education and training convention implemented to improve standards of competence of management, operational and support staff worldwide. It defines and covers three essential areas:

(a) the responsibility of shipping companies to employ competent sea-going

personnel and to provide continuous training
(b) uniform job performance competency standards
(c) issuance of certificates to sea-going personnel who meet the required competency standards.

Indeed there have been much infusion and improvements in technology on board ships in order to control and reduce the incidence as well as severity of maritime accidents, but these improvements become ineffective if crews are not trained to react properly when emergencies occur. Regulation on technical aspects of marine operation can only partly achieve the objectives of safer ship operation. Personnel competence is a critical factor in the safe and efficient operation of ships. From what has been described above three major support functions for the marine industry can be identified: (1) task-oriented specific skills training; (2) on-the-job training and advice; (3) assessment and monitoring of competency.

Characteristics of the marine industry and the requirements discussed above suggest the suitability of an EPSS approach. The way in which this can be achieved is demonstrated by a software prototype – the Electronic Lab Book (ELB) on Steam Power Plant Operation developed by the authors.

5. ELECTRONIC LAB BOOK

The objective of this software is to enhance the learning of principles behind the efficient and economical operation of a steam power plant and prepare the students to carry out practical laboratory task. The electronic lab book (ELB) is designed for use in an academic environment. It intends to minimise lecturer's briefing and intervention while preparing the student to start, run and stop an actual steam turbine in the laboratory.

Thermodynamics and Rankine Cycle is a difficult subject to teach using conventional methods. The ELB software package allows interactive operation of a simulated steam power plant and visualise the Rankine Cycle. Complete Steam Table data and the mathematical model is built into the software. The system allows the model parameters of temperature and pressure to be changed. The effects of these changes can be observed on the gauges and the dynamic Temperature-Entropy diagram.

The ELB supports active learning of the fundamentals through simulation exercises; visualising and identifying parts of a steam turbine before operating it; job aids for starting and stopping procedures with video demonstration; and assessment of competency achieved. A sample of the steam turbine starting and stopping procedure job aid is shown in Figure 2.

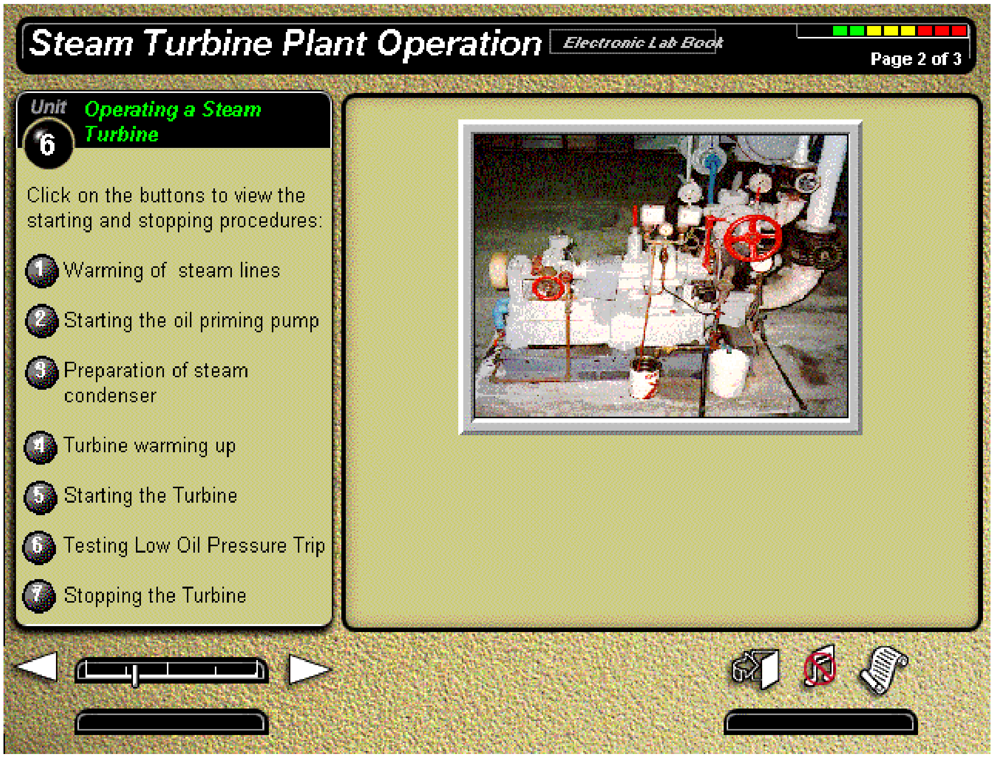

Figure 2: Video job aid in ELB

6. MARINE APPLICATIONS

In marine engineering training it is essential that the personnel gain sufficient knowledge and maintain a highly skilled performance level in operating various types of marine equipment. Multimedia training technologies together with ELB have been successfully used in marine engineering training within Singapore Polytechnic for some time (Mukherji and Chan, 1994; Banerji and Giller, 1996). The ELB approach described above represent one class of EPSS application for task oriented specific skills training. Such systems would also be useful in maintaining and monitoring competency levels as suggested in the ISM and STCW95 regulation. Following the rationale for EPSS (described in section 3) these systems would form a broad class of marine EPSS application namely '**EPSS for marine operations**'. The other class of application would be '**EPSS for marine regulations**'.

EPSS for marine operations

One example of this type of application that we are currently working on is EPSS for handling of life saving appliances. This is based upon the following analysis.

It is imperative that the members of staff in a ship are fully conversant in safe handling of essential safety equipment. Extensive familiarization program is necessary as members of staff are transferred to different vessels. Currently when a member of staff is posted on board, he is trained by his supervisor or by a visiting superintendent. There is no assessment to gauge the understanding of the personnel. A number of serious accidents have happened during normal shipboard drills. These have been attributed to improper maintenance and lack of skill or ignorance.

To avoid such situations the STCW-95 requires that a company must familiarize the officers with the essential equipment on joining a vessel and a record of their training is to be kept. Maintaining and ensuring proper competency level of staff has therefore become an urgent requirement. As a solution EPSS is considered suitable for this type of situations. Simulation of handling the lifeboat and emergency drills would give the Officers real-life experience. Further, allowing the Officers to watch the effects and control various parts of the system would make training highly effective. The Officer can be assessed and the company can monitor the requirements of the ship's personnel. It will include four items of the EPSS model namely: job aid, training, operating procedure guidance, and assessment of competency.

EPSS for marine regulations

The IMO regulations with their numerous amendments and protocols provide guidelines for ship building, major conversions and repairs. However, over the years the regulations with their protocols and amendments have become extremely complex and elaborate. The identification of relevant and correct regulation in a particular case have become a daunting task for many who are directly involved in the application of these. Even the experts in maritime industries take appreciable time and deliberations to arrive at desired solutions.

An EPSS framework could be adopted to model the complex rules and regulations documents. This will enable the users (ship designers, builders, surveyors and ship managers) to identify the relevant regulation for a particular case accurately and timely. An EPSS on this aspect will involve four items of the EPSS model namely: reference material, regulations, procedure guidance and advice.

7. CONCLUSION

The characteristics of developing skilled performance are quite different than those of learning declarative information. Teaching declarative information generally includes presenting the information once in a classroom setting. In contrast, developing skills entails presenting comparatively fewer facts but requires the learner to devote a great deal of effort in developing and practicing component skills. Under such circumstances it may be beneficial to design training procedures that will allow a student many task performance trials as have been provided within the ELB described.

The main focus of an EPSS is human-task interaction in which computers and people attempt to solve a problem or task in a cooperative way. In such situations humans use common sense reasoning, they define goals, and they decompose a problem into sub-problems that can be tackled in an appropriate way. On the other hand, computers can be used to provide an external memory and ensure consistency. They can also be used to hide irrelevant material and to summarise and visualise relevant information. In situations such as this the computer systems that are involved often act as a sort of 'cognitive amplifier'. Adopting the EPSS approach the shipping companies can ensure the competency standards for management and operations personnel and support their just-in-time training needs for safe performance.

Acknowledgment: The authors acknowledge the support received from Dr. Doreen Cheong, Head and Mr. Francis Chan, Section Head of Educational & Staff Development Department, Mr. S Das Sharma, Head and Mr. Amit Ray, Deputy Head of Maritime Technology and Transportation Department, Singapore Polytechnic, and for funding support for this project from the National Science & Technology Board, Republic of Singapore.

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