

Factors influencing Competence Retention in Safety Critical Roles

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ABSTRACT

A scoping study was undertaken on behalf of the UK rail industry to investigate those factors influencing competence retention in safety critical roles. The work comprised a brief literature review, analysis of accident data and the development of an outline competence model. This paper reports on the research methodology and principle observations. The study adopted a systems based approach to investigate factors which may influence competence retention. It included consideration of other safety critical industries including aviation, marine and military land based operations. The study highlighted the potential influence of system design on cost effectiveness and operator performance.

Keywords

Rail, Competence, Human Error Analysis, Skill Decay, Equipment Design, Individual Factors, Task Requirements, Working Environment, Training, Assessment, Workplace Organization.

INTRODUCTION

Competence is cited as a contributory factor in a significant proportion of rail incidents. Current competence management systems typically focus on training and scheduled reassessment. Research has indicated that competence retention is influenced by other factors.

The objective of the study was to investigate the influence of a range of factors on performance in safety critical roles.

METHODOLOGY

The methodology comprised the following activities:

- Development of a study framework;
- Investigation of literature and incident data;
- Development of the research questionnaire;
- Development of the outline competence model;
- Development of the competence model.

Each activity is described in further detail in the following sections.

Development of a Study Framework

The study adopted a systems approach, to permit consideration of the following factors:

- Individual Factors;
- Task Requirements;
- Working Environment;
- Equipment Design;
- Training and Assessment;
- Workplace Organization.

The framework provided a means of:

- mapping data from other industry sources;
- developing search terms for use during the fundamental literature and incident reviews;
- organizing and reporting qualitative and quantitative data;
- developing a competence model.

Investigation of Literature and Incident Data

Information was collected and reviewed from a range of safety critical industries. Fundamental literature was reviewed to identify the range of factors influencing competence retention and intervention strategies. Incident reports from safety critical industries were reviewed to identify examples related to competence deterioration.

Data sources were coded using the study framework described above.

Development of the Research Questionnaire

No fundamental literature relating to skill decay in the rail industry was identified during the survey. The majority of publications collected reported research conducted within the military and civil aviation domains. A research questionnaire was developed to identify the relevance of factors from non-rail sources to the rail industry.

The research questionnaire comprised statements derived from the fundamental literature. Statements related to factors which

influence competence retention and strategies to reduce the rate of skill decay.

Statement	Cognitive tasks are more prone to decay than physical tasks. Note, however, that this statement is questionable if there are opportunities for mental rehearsal and feedback.
Q1	Identify examples of cognitive and physical tasks which are performed by the safety critical roles under consideration.
Q2	Is there evidence e.g., within the incident data to indicate a greater frequency of incidents associated with cognitive rather than physical tasks?

Table 1 – Extract from the research questionnaire.

Statements were grouped according to the study framework. One or more queries was developed for each statement to determine its relevance to the rail industry. Those queries that related to incident data were tested. An extract from the research questionnaire, developed for the factor Task Requirement, is provided in Table 1.

Development of the Outline Competence Model

The outputs from the activities reported above enabled the development of an outline competence model.

The outline model comprised three components:

- Performance level, i.e. standard of conduct of a task;
- Influencing factors, i.e. issues affecting skill decay or performance;
- Intervention strategies, i.e. methods to improve performance.

Figure 1 illustrates the resultant outline competence model.

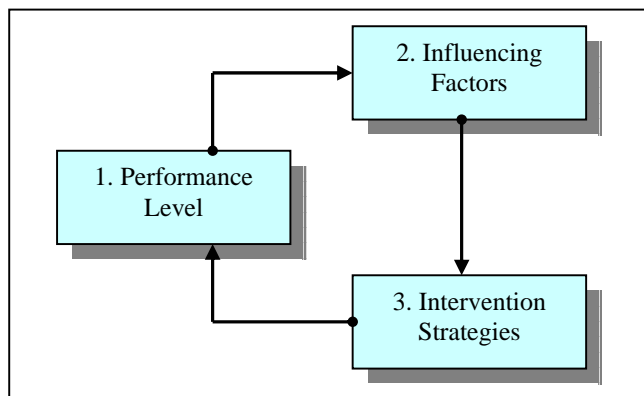


Figure 1 – Outline competence model

Development of the Competence Model

The outline competence model in Figure 1 illustrates the high level components representing competence. In order to identify effective intervention strategies, it was necessary to develop the model further. The first stage in this development

was to decompose the influencing factors to identify their underlying error mechanisms.

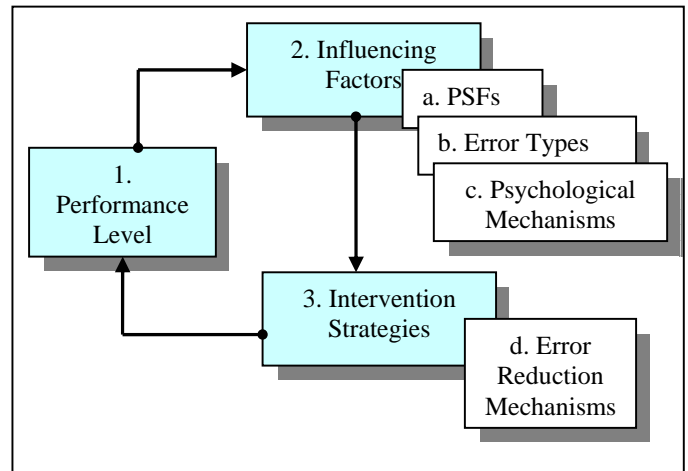


Figure 2 – Preliminary decomposition of the outline model of competence.

Human error analysis provides a range of methods to investigate factors which affect an individual’s performance. The PHECA human error analysis model was adopted by the study because its data structure correlated with the study framework.

Figure 2 illustrates the integration of the PHECA model with the outline competence model. Stages a to c represent the preliminary decomposition of the ‘influencing factors’ component of the model. Stage d represents the preliminary decomposition of the ‘intervention strategies’ component of the model.

An example of the application of the model outlined in Figure 2 is provided in Table 2.

Performance Shaping Factors	Recall of procedures
Error Type	Error of Omission
Psychological Mechanism	Forget Isolated Act
Error Reduction Mechanisms	
Individual Factors	Ensure that the individual is motivated to perform their task to the required performance level.
Task Requirements	Ensure that consideration is given to the use of mental rehearsal and feedback, as this will benefit the recall of procedures.
	Ensure that safety steps form part of the memorized task sequence structure.
	Ensure that specific

Performance Shaping Factors	Recall of procedures
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Psychological Mechanism	Forget Isolated Act
Error Reduction Mechanisms	
	consideration is given to decision making tasks, as these are more prone to skill decay.
Equipment	Ensure that equipments provide the necessary task feedback to the operator.
Training and Assessment	Ensure that consideration is given to the use of overlearning as a training technique.
	Ensure that consideration is given to the use of job aids and automation in addition to refresher training.

Table 2 – Example application of the competence model.

OBSERVATIONS

Observations related to the following areas:

- Systems based approach;
- Common ground between safety critical industries;
- Development of competence model – use of PHECA;
- Limitations with incident data reporting and analysis;
- Individual characteristics.

Systems Based Approach

The study identified that the range of factors described in the study framework can influence competence retention. This is illustrated by the extract of the research questionnaire presented at Table 3.

Id	Statement
Individual Factors	The influence of motivation and individual differences on skill retention should be investigated.
Equipment	The quality of task feedback impacts skill decay.
Task Requirements	A logical flow between tasks can reduce the incidence of steps being excluded inadvertently from a task sequence.
Training and Assessment	Training and assessment strategies to improve skill retention tend to underestimate the importance of effective skill acquisition.

Table 3 – Examples of the range of factors that can influence competence retention.

Common Ground between Safety Critical Industries

Initial study findings from incident reports indicated similarities in influencing factors between safety critical roles within the rail, marine and aviation sectors. Table 4 illustrates this relationship.

Factors	Rail Incident Reports	Air Accident Reports	Marine Accident Reports
Individual Factors	√	Not identified in sample	Not identified in sample
Task Requirements	√	√	√
Working Environment	√	√	√
Equipment	√	√	√
Training & Assessment	√	√	√
Workplace Organization	√	√	√

Table 4 – Summary of common factors between safety critical industries.

As noted above a research questionnaire was developed to identify the relevance of factors from non-rail sources to the rail industry. Those queries which related to incident data were tested. The output of this exercise indicated a relationship between those factors most prone to skill decay and those factors which were cited as contributing to incidents. Table 5 illustrates this relationship for communication tasks. The statement in Table 5 was extracted from Rullo et al (1990) who undertook a review of the literature on skill decay across a range of safety critical industries.

In the following classification scheme there is a general increase in proneness to skill decay from tasks a-j with voice communication tasks showing the greater proneness to skill decay.		
Classification system:		
(a) Attitude learning; (b) Gross motor skills; (c) Steering and guiding – continuous movement; (d) Positioning movement; (e) Detecting; (f) Making decisions; (g) Recalling bodies of knowledge; (h) Classifying-recognising patterns; (i) Recalling procedures; (j) Voice communicating		
Safety Critical Role(s)	Summary of incident	Source Data
Train Driver and Signaller	Inadequate voice communications between the Training Driver and Signaller identified as one of the contributory causal factors.	HSE SPAD Report for February 2003.

Train Driver and Signaller	A deficiency in voice communication between the Signaller and Train Driver was a contributory factor in this incident.	HSE SPAD Report for November 2002.
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Table 5 – Extract from the output of the Research Questionnaire.

Whilst the above provides initial evidence for common ground between safety critical industries, the observation should be treated with caution. For example, an analogy is commonly made between the work of the Railway Signaller and the Air Traffic Controller. Both jobs are safety critical and require the management and control of vehicles passing through sectors under their control. Consideration of the communication requirements of the two jobs, however, indicates key differences between these two roles. Air Traffic Controllers use voice communications as a main way of informing their job. In contrast, Signallers only use voice communications sporadically, e.g., during emergency situations. The purpose and frequency of voice communications differs between these roles. These differences highlight the potential pitfalls of applying findings developed from one industry to another.

Development of Competence Model – use of PHECA

The study extended the typical use of human error analysis to inform the development of a model of competence. Application of PHECA proved an effective means of analyzing and representing competence deterioration and intervention strategies.

Limitations with Incident Data Reporting and Analysis

There is no consistent format for the reporting of incident data. Furthermore, the personnel involved in incident data collection may not be suitably trained to identify factors relevant to skill decay.

The incident data reviewed was not presented in a format consistent with the study framework. Access to Subject Matter Experts to assist in the interpretation of this data was not available. Consequently, incident data was recoded by a third party. This created the potential for misinterpretation in coding.

Individual Characteristics

Many of the articles reviewed indicated that limited research has been undertaken to investigate the influence of individual differences on skill decay. For example, the influence of individual motivation upon both skill acquisition and retention was cited as an area that required further investigation.

NEXT STEPS

The following next steps are proposed:

Systems Based Approach

Factors rarely act in isolation and the inter-relationships between them can be complex. Interactions between influencing factors should be considered in future work.

Common Ground Between Safety Critical Industries

Future work should consider the development of a methodology, e.g., in the form of a checklist, for determining the extent to which common ground exists between safety critical industries.

Development of competence model – use of PHECA

Further development of the competence model should be undertaken. This should include consideration of its use as a predictive modeling tool. For example, to identify potential areas of competence deterioration prior to an incident occurring. The use of other systems based methodologies should be considered in this development.

Incident data reporting

The feasibility of developing a common framework for reporting incidents that supports subsequent Human Factors analyses should be investigated. A means of acquiring data to identify early indicators of skill decay should be investigated.

Individual characteristics

Research into the role of individual characteristics in competence retention should be investigated. For example, the relationship between the rate of skill acquisition and decay should be investigated.

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