Development and Utilization of Educational Material for Human Factors*

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Abstract
In this paper, I describe the Safety Research Institute and give details concerning the institute’s human factors textbook and the educational program that has been developed using this textbook. The human factors textbook was created in order to shed light on human factors and mechanisms leading to human error. Thirty-two items were selected from general knowledge about human factors and these items were discussed using familiar examples and clear, non-technical explanations. An educational program, consisting of a series of lectures based on the principles covered in the textbook, has been created in order to further the understanding of human factors. The contents of the educational program have been arranged based on the needs of the students. Furthermore, we conducted a survey in which students were given a questionnaire in order to examine the educational effects of the textbook and lectures, and we are using these results to refine our programs. According to the results of the questionnaire, the lectures have received high ratings in terms of understandability and satisfaction. The results regarding the level of difficulty indicate the material covered in the lectures was at a level appropriate for the students.

Key words: Human Factors, Educational Material

1. Introduction

On April 25, 2005, our company was involved in a major railway accident. We received a lot of advice that we are lacking in viewpoint of human factors. Based on reflections and lessons learned from this incident, and on the premise that since human errors are unavoidable, we must take into account all factors that will allow us to mitigate the frequency and severity of errors, the Safety Research Institute was established in June 2006. The Safety Research Institute has 30 researchers in total. They are specialists in railway systems, specialists in psychology, and people from other railway companies and industries. We promote research for the purpose of railway safety.

For enhancing railway safety, it is important to improve research from the viewpoint of human factors, and that all employees understand human factors. It has been recognized that knowledge of human factors is an important aspect of safety education, and many industries have developed safety education systems incorporating educational materials on human factors¹⁰⁻¹³. However, we did not previously have an educational system based on human factors and did not fully understand human factors and methods of preventing human errors based on empirical research.

Hikono¹⁴ has reviewed the literature on human factors education, human factors training, CRM training and safety training, and has proposed a new educational concept, by emphasizing the need for employees to understand human factors related lessons from the
past, using examples of accidents and countermeasure that are specific to each companies, in order to improve comprehensibility of education. Accordingly, it is necessary to develop original educational material and conduct educational programs that increased employees' interest in human factors. Therefore, we developed the textbook “The Human Factor – examples from real-life” in order to facilitate the understanding of human factors and mechanisms involved in human error. Furthermore we conducted an educational program consisting of a series of lecture, and conducted a survey to examine the effects of the educational program.

2. Development of educational materials based on human factors

This textbook must be studied by every employee. There must be a copy at every worksite and employees should try to apply the information contained in the text to their jobs on a daily basis. We therefore tried to explain the material covered in the text in simple terms and illustrate the concepts with familiar examples based on real-life situations. A committee that included some of researchers in our institute was convened in order to develop this textbook, and all members of our institute had a hand in writing the material. The committee members spent six months in discussions regarding the content and writing of this text. The details of the textbook are as follows.

2.1 Product detail

Total number of pages: 100
Printed and Distributed: This textbook was distributed to every employee in our company, and furthermore other railway companies and other industries expressed interest in this textbook, so in total we published about 74,000 copies.
Issuance: March 2007

2.2 Chapters and Items

Thirty-two items that were regarded as associated with our industry were selected from general knowledge concerning human factors. These items were selected based on information found in psychology and ergonomics textbooks as well as human factors texts that have been developed by other industries. We selected items that dealt not only with the characteristics of individuals, but also looked at a variety of issues related to human interaction. These included interfacing, group dynamics, and management. This approach was taken because to properly investigate the causes of accidents and create effective safety measures, we must focus on human factors that are associated with both individuals and groups.

These 32 items were classified into 4 chapters: physiology, psychology, management and group dynamics. The chapters and items are shown in Table 1.

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Physiology</th>
<th>Psychology</th>
<th>Management</th>
<th>Group dynamics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fatigue</td>
<td>Attention</td>
<td>Safety culture</td>
<td>Leadership</td>
</tr>
<tr>
<td></td>
<td>Monotony</td>
<td>Illusion</td>
<td>Incident</td>
<td>Reward and punishment</td>
</tr>
<tr>
<td></td>
<td>Sleepiness</td>
<td>Memory</td>
<td>Safety management system</td>
<td>Drive</td>
</tr>
<tr>
<td></td>
<td>Habituation</td>
<td>Unusual situation</td>
<td>5S</td>
<td>Small group activity</td>
</tr>
<tr>
<td></td>
<td>Stress</td>
<td>Risk-taking</td>
<td>Manual</td>
<td>Conformity</td>
</tr>
<tr>
<td></td>
<td>Environment</td>
<td>Violation</td>
<td>Basic motions</td>
<td>Social loafing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Automaticity</td>
<td>Finger-pointing and call</td>
<td>Bystander effect</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Interruption</td>
<td>Double check</td>
<td>Generation gap</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Human interface</td>
<td>Difficulty of communication</td>
</tr>
</tbody>
</table>

The book begins with an introduction that defines human factors and human error. In chapter 1, human factors related to physiological aspects, such as drowsiness and stress are explained. The human information processing system and the role that such factors as
memory, attention, risk-taking, and illusion play in human errors are covered in chapter 2. In chapter 3, we discuss institutional rules for safety measures, such as guidelines for basic motions, safety management systems, and the creation of an institutional culture that prioritizes safety. This chapter also details elements involved in interfaces that occur between humans and machines. Chapter 4 covers group dynamics, such as leadership, communication between superiors and subordinates, and workplace generation gaps.

2.3 Page format
The explanation of each item is formatted with the aim of enhancing readability. Each item is covered in the space of two facing pages, meaning that all the information contained for each item can be read without flipping through the pages of the book. Each item contains 3 sections: examples, explanation and countermeasures.

In the examples section, 2 or 3 examples related to daily operations in our industry are presented in clear, non-technical language. These examples were taken from real-life situations and were based on the experiences of researchers at the institute or on documented occurrences. This was done in the hope that readers would find that these examples seem familiar to them. The themes illustrated by the examples are arranged in a way as to not emphasize any specific work setting.

In the explanation section, the psychological and ergonomic findings are illustrated with figures and tables.

In the countermeasures sections, we suggest practical and constructive countermeasures to help prevent human errors. Each item in the book is followed by a list of references.

An example of the content of this textbook is shown in Fig. 1.

3. Educational programs using this textbook
The Safety Research Institute has not only developed this textbook, but has promoted an educational program using this textbook in each field in our industry. Over the course of two years, there have been more than 100 lectures using this textbook and more than 3000 employees have attended these lectures. Most of these lectures have been held in response to requests from people employed in various fields in our industry. In this lecture, we discuss human factors and suggest ways in which members of various fields can become familiarized with human factors. We also illustrate how looking at human error from this viewpoint can help increase workplace safety.
3.1 Content of the Educational Program

Most of the lectures ranged in length from 45 minutes to 90 minutes. This included a lecture and a discussion period. An example of a typical program is as follows.

1. Introduction
   Explanation of the Safety Research Institute

2. Human Errors and Human Factors
   Explanation of the concept that human errors are an unavoidable fact of life
   Introduction to the meaning of “Human Factors” using familiar examples

3. An in depth looks at Human Factors
   Discussion of human errors caused by human factors that are covered in the textbook
   Participants recall their own mistakes or errors and relate these experiences to human factors
   Examples of visual illusions help them better understand human factors and human errors

4. Discussion, questions and answers

   The examples that we use in each lecture must be familiar to all the students, so the details of the program are varied according to the participants. For example, if the students are train drivers, examples taken from their worksites are incorporated into the lecture, and if the students are entry-level employees, we attempt not to use highly technical examples.

   In the early phases of development, we mainly relied on the textbook to discuss human factors, but gradually we have managed to incorporate data gained from our research to be used in parallel with the text. Furthermore we have used examples of human error or accidents that have occurred in other fields, such as the airline or power industry.

   Example of scenes from the lectures is shown in Fig. 2.

4. Effect of the Human Factors Lecture

   We conducted a survey using a questionnaire in order to check the educational effects of our lecture and to refine the textbook and the lecture. In this survey understandability, satisfaction, difficulty, and further interest in the lecture were measured.

4.1 Method

   The survey consists of four questions. The questions and answer choices that we used are as follows.
1. Understandability
   How understandable was the lecture?
   1: not very understandable 5: very understandable
2. Satisfaction
   How satisfied were you with the lecture?
   1: not very satisfied 5: very satisfied
3. Difficulty
   How would you rate the difficulty of the lecture?
   1: too easy 3: suitable 5: too difficult
4. Further interest
   Would you be willing to attend another lecture about human factors?
   1: not willing to attend 4: willing to attend

Questions 1, 2 and 3 were rated on a 5-point scale and question 4 was rated on a 4-point scale. We also asked participants to tell us their age group (18-29, 30-39, 40-49 and over 50), worksite location, and position in the company. We prepared a space on the questionnaire where participants could give opinions and comments regarding the lecture.

Due to time constraints, we could not administer the survey at some of the lectures. From April 2007 to December 2008, we administered the survey at 41 different lectures to 1,608 students.

Surveys were administered at the end of each lecture. It took about 5 to 10 minutes on average for the participants to complete the questions and give their comments. The anonymity of research participants was protected.

4.2 Results

Questionnaire. Means and SD for understandability, satisfaction, difficulty and further interest are presented in Table 2.

<table>
<thead>
<tr>
<th></th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>understandability</td>
<td>4.27</td>
<td>0.66</td>
</tr>
<tr>
<td>satisfaction</td>
<td>3.96</td>
<td>0.62</td>
</tr>
<tr>
<td>difficulty</td>
<td>2.82</td>
<td>0.48</td>
</tr>
<tr>
<td>further interest</td>
<td>3.10</td>
<td>0.58</td>
</tr>
</tbody>
</table>

Understandability, satisfaction and difficulty were measured on a 5-point scale, further interest on a 4-point scale. Difficulty is a reverse item.

Analysis of variance indicated that the main effect of age group was not significant in understandability, satisfaction, and further interest. This result indicates that understandability, satisfaction, and further interest did not vary among age groups.

Opinions and Comments. Representative examples of opinions and comments are shown in Table 3.

<table>
<thead>
<tr>
<th>Advantages of the lecture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explanations are given using examples</td>
</tr>
<tr>
<td>Questions and problems are presentation during the lecture</td>
</tr>
<tr>
<td>Using the textbook with this lecture as a start</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disadvantages of the lecture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Need more specific countermeasure</td>
</tr>
<tr>
<td>Need more quick-acting countermeasures</td>
</tr>
<tr>
<td>Need more accident examples</td>
</tr>
<tr>
<td>Need more time</td>
</tr>
</tbody>
</table>

Table 2 Means and SD of understandability, satisfaction, difficulty and further interest

Table 3 Examples of opinions and comments of students
4.3 Discussion

The questionnaire was administered in order to measure the effect of the lecture and to provide us with feedback.

The results of the questionnaire show that the understandability of the lecture and satisfaction with the lecture were both rated highly. Furthermore, the comments and opinions of the students indicated that the examples we used were seen as memorable and easy to understand. These results indicate that the principles used in the development of the textbook produced meaningful results for the students in the lecture. The responses related to the difficulty of the lecture show that the level of difficulty in the lecture was appropriate for the students. Although lectures covering human factors or human error tend to be considered as involving complex issues, the readability of the textbook and the accessible examples in the text and the lecture may have helped students understand these concepts.

From the comments and opinions given by the participants, we can gain insight into issues that still need to be addressed. First, we must attempt to suggest more specific and effective countermeasures that will aid in preventing human error. The text and lecture were based on the premise that the examples and the explanations detailing human factors must be familiar and of interest to the students. This also needs to be applied to the discussion of countermeasures. This will provide not only background information, but also practical knowledge that can be applied daily in the workplace. Second, we must attempt to use more examples containing details that are recognizable to students in various fields. Cases involving specific worksites or specific jobs should be prepared.

5. Conclusion

We have been promoting safety education and training through our textbook and our lectures. To improve our educational programs, we continue to analyze and utilize the results of the questionnaire and the impressions of the students.

Acknowledgements

The textbook was developed by all researchers of the Safety Research Institute. I presented this paper on behalf of them.

References