The Latest Research on Human Factors at the Safety Research Laboratory

Manager (Human Factors), Safety Research Laboratory, Research and Development Center of JR East Group

Shin-ichi Aonuma

JR East’s Safety Research Laboratory has been making efforts in research on human factors as one of its mainstay activities since inception in 1989. As the framework of current research, we periodically identify safety issues by means such as questionnaire surveys of employees and reflect the results in safety measures. Based on survey responses, we next conduct research with “increasing the level of people” (research such as that on deepening understanding of errors from a human factor standpoint to improve error prevention skills), “improving safety abilities of the workplace” (research such as that on methods to improve teamwork by sharing information and improving convincingness through communication), and “forming safe systems” (research such as that on design of optimum human-machine interface) as the three mainstays. This article introduces the latest research on human factors and covers the future orientation of research.

Keywords: Human factor, Human error, Human-machine interface

1 Introduction

JR East’s Safety Research Laboratory has been conducting research from viewpoints such as safety assessment, rolling stock, and maintenance work since its inception in 1989. For human factors, we have been conducting research in the framework shown in Fig. 1.

In “increasing the level of people,” we are conducting research on how to interview at accident investigations. In “improving safety abilities of the workplace,” we are conducting research on methods of training human resources related to improving safety abilities. And in “forming safe systems,” we are conducting research on optimizing the composition of equipment related to the train driver’s cab.

This article introduces the latest research we are working on concerning human factors and covers the future orientation of research.

Fig. 1 Framework of Research on Human Factors

2 The Latest Research on Human Factors

2.1 Research on Employee Awareness of Safety

(1) Purpose of research

JR East establishes a five-year safety plan every five years, based on which we conduct safety measures. To continuously improve safety at JR East, it is important for us to identify awareness of safety by employees at the front lines of maintaining the safety of transport. We thus conduct questionnaire surveys of JR East and group employees, analytically assess the results of those, extract weaknesses (risks) and issues in employees’ safety awareness and safety, and conduct research to extract items such as measures needed to improve safety at JR East.

(2) Overview of survey

We conducted questionnaire surveys to identify the current state of safety along with safety issues and the future required framework from the viewpoints of the entire company, workplace and individual (hereinafter “three viewpoints”). The surveys were done for approx. 55,000 employees of JR East and group companies, and the response rate was 87.7%.

(3) Survey results

Questionnaires were structured so we first ask about the company’s safety level (issues such as changes over the past few years in safety related to items such as human errors and train failures) from the three viewpoints to identify the current situation. Then we ask about future issues and efforts (items such as those important for further raising safety). Results for safety improvement from the viewpoint of the entire company are shown in Table 1 as an example of analysis results. Items that gained many responses compared to others were “equipment investment for safety measures” and “awareness of safety by individuals,” demonstrating that many employees feel that safety improvement is being achieved by both objects and people.
Table 1 Items Important in Increasing Safety

[Top five selected]
1. Equipment investment for safety measures
2. Awareness of safety by individuals
3. Improvement of technical ability, passing down technologies and skills
4. Workplace atmosphere
5. Observation of basic actions

The results of surveys in this research are reflected in the “2013 Safety Vision” that has been deployed since fiscal 2009. In the future, we plan to periodically identify employee awareness and reflect that in safety plans.

2.2 Research on How to Interview People Involved when Investigating Accidents

(1) Purpose of research
The purpose of interviewing people directly involved with the error when investigating an accident or event that occurred as a result of human error is to accurately find the process and cause of the accident and process by which it occurred. It is also to gain the information needed to prevent occurrence or reoccurrence of accidents. We thus compiled interviewing skills in a variety of ways and arranged components of those skills so as to effectively train new investigators on methods of interviewing in accidents that occur as a result of human error.

(2) Survey on existing findings regarding interviews
(i) Arrangement of knowledge from a clinical psychology perspective
In investigations, it is important to take into account the psychological state of those involved and to stress that the purpose is solely “to gain information needed to prevent occurrence or reoccurrence of accidents.” Doing so has benefits such as creating an atmosphere where those involved are more inclined to talk.

(ii) Arrangement of knowledge gained from other industry surveys
In addition to the content of (i) above, it is also important to take care not to excessively make assumptions or presumptions and not rely solely on techniques and knowledge gained through past investigations. Interviews should be made from a variety of viewpoints for factors that may have an influence on results.

(iii) Conducting interviews with those involved in accidents
In order to arrange methods of holding interviews for JR East accident investigations and skills related to those, we spoke with highly skilled JR East accident investigators regarding skills related to interviews. A total of 22 personnel were selected from various organizations including the Transport Safety offices that coordinate safety at branches as well as transport-related (crew, rolling stock, etc.) and equipment-related (line maintenance, construction, etc.) sections. Those personnel were interviewed individually.

In those talks, the investigators also pointed the large amount of clinical psychology and other industry investigations used as interview methods. Those facts demonstrated that highly skilled accident investigators in effect understand the importance of existing knowledge though means such as their own experiences.

2.3 Research on Methods to Monitor Soundness of the Organization

(1) Purpose of research
Risks and factors behind them need to be identified to continuously improve safety. Continuous monitoring of an organization to identify situations such as whether or not it is sound in terms of safety and whether it is heading in a good or a bad direction is important. In this research, we feel that

As a result of classifying the acquired interviewing skills, we found we could arrange those into five major elements (Fig. 2). The main points of those are abbreviated below.

(i) Building a “relationship of trust with those involved
It is important to have the interviewee understand that the purpose of the interview is not to pursue the responsibility of those involved and that human errors are also caused by external factors. A relationship of trust is needed to have those involved speak frankly.

(ii) Gathering accurate information from people whose memories may not be reliable
People tend to forget things as time passes, so the first interviews are held as soon as possible. Efforts also need to be made to prevent the content of interviews from being too narrow due to reasons such as speculation by the interviewer and to visually work on recollection using tools such as diagrams and photographs.

(iii) Searching for mechanisms and trigger factors of errors
Effective countermeasures differ depending on the details (mechanism, etc.) of the error. It is thus important to extract broadly from a 4M (Man, Machine, Media and Management) perspective complex and multifaceted error factors including problems in areas such as the organization and management.

(iv) Assessing the testimony of those involved
To compensate for the weakness of human memories, we compare testimonies with objective physical data based on records such as those of signals and rolling stock. That allows us to confirm whether or not testimonies are biased from the standpoints of those involved.

(v) Effective studying of countermeasures and training of those involved in errors
Interviews are for more than just gaining information helpful in preventing occurrence or reoccurrence of accidents. They are extremely useful as opportunities for educating those involved in errors to raise their awareness of safety. Interviews thus are important in motivating for future efforts in safety.

Fig. 2 Arrangement of Factors That Make Up Interviewing Skills

(i) Building a “relationship of trust with those involved
(ii) Gathering accurate information from people whose memories may not be reliable
(iii) Searching for “mechanisms and trigger factors of errors”
(iv) “Assessing the testimony” of those involved
(v) Effective “studying of countermeasures” and “training” those involved in errors
diagnosing monitoring of the soundness of the organization through assessment of the state of efforts related to safety is an effective viewpoint. We thus arranged the overall framework for diagnosis.

(2) Overview of research
One method of monitoring the organization is an evaluation method by employee questionnaires called “safety culture diagnosis”. Results at the time the questionnaire was taken are assessed with that method, but it does not mean a good state will be maintained into the future, even if positive results are gained. We thus decided to focus on the process up to the results and assess the process of day-to-day activities to raise safety instead of results of a single point in time. Specifically, we decided to diagnose by the following four steps (PDCA cycle).

(i) Are the necessity and aims of efforts in safety activities “understood?”
(ii) Are the aforementioned activities “conducted” upon understanding of them?
(iii) Is “effectiveness” increased as a result of conducting activities?
(iv) Are activities continuously “improved” upon identifying their status?

To assess the process at JR East, we need to identify at the individual levels. These levels encompass the companywide organization from the frontline employee (individual) who is the basic unit of the organization through the workplace organization, branch, and head office. We thus decided to carry out diagnosis in the following three hierarchies, taking into account issues such as structure of the organization and the actual situation at the workplace.

(i) The level of promoting “efforts to raise one’s own qualifications (knowledge, skill, awareness, etc.)” because safety is secured by the appropriate actions of frontline employees
(ii) The level of promoting “workplace-level efforts” where qualifications of frontline employees are raised in an organized manner
(iii) The level of promoting “efforts related to the management system” at the head office and branches that lead and support the aforementioned efforts

![Fig. 3 Model of Viewpoints in Monitoring Soundness of the Organization](image)

We utilized those indexes and confirmed their effectiveness by questionnaire surveys of branch employees. The results demonstrated a possibility of using those as a method of diagnosing the status of promoting safety-related activities.

In the future, we plan to establish a monitoring method. This will be done while studying items such as improvement of questions for the head office, branch, workplace and individual, linkage with the periodic survey on employee awareness of safety covered in section 2.1, and qualitative assessment of errors that occur. (Joint research with Waseda University: See page 21 for details of that research.)

2.4 Research on Methods of Human Resource Development Related to Improving Safety Abilities

(1) Purpose of research
As a safety issue, items learned such as the content of lectures related to safety taught in venues such as group training must be put to use in day-to-day work. We thus researched effective training system to make content of training become entrenched at the worksite while being aware of the problem of how to lead to that being practiced at the worksite.

(2) Creation of training models
In the initial stage of research, we conducted a bibliographical survey on corporate human resource development methods. In that, we created the ideal model for overall research mainly by referencing documents.

Specifically, we identified training needs of trainees beforehand to design training curriculum upon creating solid objectives for training. After that, we designed training by merging “instructional design” where we consider the overall situation up to post-training assessment with “learning environment design” where we consider an environment which the content learned in group training is incorporated into and functions in day-to-day work.

From an “instructional design” viewpoint, for example, we were strongly aware of the connection between pre-training, training, and post-training. We thus created a system where superiors participate in pre-training activities, some training, workplace practice (5 months), and review (5 months) so the trainees can receive support as need. In pre-training activities in particular, setting issues with superiors allowed for sharing of the training objectives. From a “learning environment design” viewpoint, we put emphasis on interaction with lecturers and other trainees in all sorts of lectures, introducing learning that is interactive rather than simply being transmitted one-way. We also felt that facilitated methods where a facilitator questions using examples of others to convince trainees could be utilized in workplace meetings and the like.

(3) Results
We conducted training for crew offices related to transport at the Tokyo branch. For pre-training issues that were brought up, we implemented an action plan at the workplace after training that was created while receiving advice from superiors, and we presented that plan at the review five months later. From workplaces where effective results were seen while coordinating with co-workers, we extracted common requirements that can be utilized in furthering the results of training and at the workplace.

(i) Instructional design viewpoint
a. Sharing training objectives and content
Crew offices where training objectives can be shared with superiors and those around the trainee do more than just affect
the motivation of the trainee. They also provide the benefit of sharing objectives and content with superiors, co-workers, and subordinates.

b. Coordinating with others
Crew offices where coordination is normally achieved with superiors, co-workers, and others tend to be able to start action plans right after training.

c. Setting a venue for review
Having a venue for review after training leads to ability to compel execution of the action plan. But setting up a process for trainees to learn about actual problems and issues while reviewing results is thought to be a condition for raising the effects of education.

(ii) Learning environment design viewpoint

a. Effects of communication
Many trainees consider communication with lecturers and other trainees as a condition for improving the effects of learning. We have also found that much of lectures with communication were memorable to trainees.

b. Learning from others
In training, we held lectures by outside lecturers, and trainee interviews showed that those were the most memorable. We saw as a result of that, trainees looked for ways to overcome safety-related issues by comparing them with those of their own workplaces in areas such as improving tool management at maintenance workplaces.

(3) Learning environment design viewpoint

(ii) Technical study on needs and analysis of work

(i) Consolidation of crew needs (questionnaire)
(ii) Technical study on needs and analysis of work
(iii) Construction of mockup
(iv) Assessment using mockup
   a. Assessment based on ergonomic guidelines
   b. Assessment while listening to opinions of all crew members through group assessment that utilizes facilitation
   c. Assessment of scenario analysis that assesses risk of changes in composition of equipment through running in an actual section between two stations
   d. Analytic assessment of collisions
(v) Creation of final mockup
   a. Finalization of basic specifications

3 Future Research Issues

3.1 Future Research Issues Concerning Human Factors

(1) Penetration of human factor education
Penetration of human factor education is a future research issue concerning increasing the level of people and improving safety abilities of the workplace. Human factor education to prevent human errors sometimes is not put to good use in one's work. This can happen when one thinks that he or she understands in intellectual training such as desk study but cannot put gained knowledge to use at work.

We thus studied as a form of human factor education explaining the mechanism of errors while actually experiencing them. Doing so could increase an individual's level of understanding (convincement) and, when back at the workplace, make what was learned easier to apply to work. It can also lead to employee training to heighten sensitivity to hazards.

(2) Optimization of the method of displaying information in the train driver's cab
In forming safe systems, we have found that the combination of a lack of knowledge by train drivers and lack of information in the cab may result in improper handling by the crew in emergencies. That was seen in basic research on the phenomenon of blanks in memory at emergencies, a past research theme by the Safety Research Laboratory.

We thus plan to identify the current state of problems with train driver's cab information by interviews, analysis of transport disorder data, and simulator training for emergencies. And we will conduct research on train driver's cab display methods so that appropriate measures can be taken in emergencies. They will allow us to propose the optimal method of displaying information for train crews.

Reference: